Government of **Western Australia**
Department of **Water**

Esperance Water Reserve

Drinking water source protection plan

Esperance town water supply

Looking after all our water needs

Water resource protection series
Report WRP 134
October 2012

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Department of Water

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Preface

How do we protect public drinking water source areas?

The *Australian Drinking Water Guidelines* (ADWG) (NHMRC & NRMMC 2011) outline how we should protect drinking water in Australia. The ADWG recommends a 'catchment to consumer' framework that uses a preventive risk-based and multiple-barrier approach. A similar approach is recommended by the World Health Organization.

The 'catchment to consumer' framework applies across the entire drinking water supply system – from the water source to your tap. It ensures a holistic assessment of water quality risks and solutions to ensure the delivery of a reliable and safe drinking water to supply your home.

A preventive risk-based approach means that we look at all the different risks to water quality, to determine what risks can reasonably be avoided and what risks need to be minimised or managed. This approach means that the inherent risks to water quality are as low as possible. A multiple-barrier approach means that we use different barriers against contamination at different stages of a drinking water supply system.

The first and most important barrier is protecting the catchment. If we get this barrier right, it has a flow-on effect that can result in a lower cost, safer drinking water supply. Other barriers against contamination include storage of water to help reduce contaminant levels, treating the water (e.g. chlorination to deactivate pathogens), maintenance of pipes and testing of water quality. Another community benefit of catchment protection is its complementary nature to conservation initiatives.

Research and experience shows that a combination of catchment protection and water treatment is safer than relying on either barrier on its own. That's why this drinking water source protection plan is important. We should not forget that ultimately it's about protecting your health, and about protecting the catchment's water quality now and for the future.

In Western Australia, the Department of Water protects public drinking water source areas (PDWSAs) by putting the ADWG into practice, writing plans, policies and guidelines, and providing input into land-use planning.

The *Metropolitan Water Supply Sewerage and Drainage Act 1909* (WA) and the *Country Areas Water Supply Act 1947* (WA) provide us with important tools to protect water quality in proclaimed PDWSAs. These Acts allow us to assess and manage the water quality contamination risks from different land uses and activities. We work cooperatively with other agencies in the implementation of this legislation.

This drinking water protection plan has been developed to achieve elements two and three of the 12 elements recommended for the protection of drinking water in the ADWG. It shows where the PDWSA is located, its characteristics, existing and potential water quality contamination risks, and recommendations to deal with those

risks. Our regional offices then work with the community, other government agencies and landowners to put these recommendations into practice.

An important step in maximising the protection of water quality in PDWSAs is to define catchment and recharge area boundaries, priority areas and protection zones to help guide land use planning and to identify where legislation applies. There are three different priority areas. Priority 1 (P1) areas (e.g. Crown land) are defined and managed to ensure there is no degradation of the quality of the drinking water source using the principle of risk avoidance. Priority 2 (P2) areas (e.g. rural zoned land) are defined and managed to maintain or improve the quality of the drinking water source using the principle of risk minimisation. Priority 3 (P3) areas (e.g. urban or commercial zoned land) are defined and managed to maintain the quality of the drinking water source for as long as possible using the principle of risk management. Protection zones surround drinking water abstraction bores, so that the most vulnerable areas are protected from contamination.

If you would like more information about the ADWG and how we protect drinking water in Western Australia, go to <www.water.wa.gov.au>.

The following table outlines the stages involved in the preparation of this drinking water source protection plan:

Stages in development of a plan		**Comment**
1	Previous drinking water source protection plan published. (September 1999)	The *Esperance Water Reserve water source protection plan* was published by the Water and Rivers Commission.
2	Conduct stakeholder consultation. (2011)	Advice sought from stakeholders using the 1999 protection plan and recent modelling data as a tool for information and discussion. Draft updated protection plan is prepared.
3	Consult draft drinking water source protection plan. (May-June 2012)	Draft protection plan released for a four-week public comment period.
4	**Publish approved drinking water source protection plan.** **(October 2012)**	**Final protection plan published after considering submissions. Includes recommendations on how to protect water quality. Proposed amendments to the boundary of this public drinking water source area can now be progressed.**

Summary

Esperance is located on the south coast of Western Australia, approximately 600 km south-east of Perth. Esperance's drinking water is supplied from 33 production bores located within and to the west of the town. These bores draw water from an unconfined aquifer, at depths ranging from around 2 m to 55 m. The shallow unconfined nature of the aquifer means that the source is highly vulnerable to contamination from land uses and activities located within the Esperance Water Reserve.

The *Esperance Water Reserve water source protection plan* was first published in 1999. The 1999 plan provided an assessment of the risks to the water source and recommended strategies to manage those risks. Fourteen key recommendations were made, two of which are no longer applicable. Eight of these recommendations have been carried out and three are ongoing. Implementation of the remaining recommendation to support the Department of Environment and Conservation initiative to include vacant Crown land into the Butty Harbour Nature Reserve, subject to recognition of public water supply requirements, has begun. This document replaces the 1999 plan, as it provides more up-to-date information.

The Esperance Water Reserve was first proclaimed under the *Country Areas Water Supply Act 1947* (WA) in 1970. In response to new information in the 1999 *Esperance Water Reserve water source protection plan,* the boundary was reproclaimed in 2001 encompassing amendments to the water reserve boundary to ensure protection of the drinking water source.

The Esperance Water Reserve is designated as a special control area within the *Shire of Esperance Local Planning Scheme No. 23* gazetted on 19 February 2010. In making decisions on development applications within this area the Shire of Esperance has regard to drinking water source protection requirements and advice.

Land uses and activities within the water reserve include urban land uses (such as residential, commercial and irrigated parks and ovals), rural residential, extractive industry, vegetated reserves, recreation (including a rifle range and off-road vehicle use) and a former landfill site.

A groundwater flow model of the aquifer system was developed in 2010. Particle track simulation was used to delineate production bore capture zones, flow path lengths and travel times. The results of this modelling have been used in updating the risk assessment of land uses and activities within the water reserve and assessing the current boundary, priority areas and wellhead protection zones. Recommended updates to the water reserve boundary are:

- removing a wedge of land directly south east of Pink Lake, and as far east as Garden Road at one point. This area contains the Pink Lake Country Club Golf Course, a number of private blocks surrounding the golf course and a former landfill site (see Figure A3).
- removing a coastal strip of land which is currently a mix of P2 and P3. This section covers all of the coastal area that is currently P3 and extends east into

the P2 coastal area, extending from Twilight Beach Road south to the coastline.
- changing two P2 areas to P3 areas, reflecting the zoning of the area and changing two P2 area to P1 to reflect the zoning of the area as conservation and recreation.

The Shire of Esperance has been consulted about these changes and the planned development of Esperance has been discussed.

Three of the eight key recommendations in this plan are to:

- change the water reserve boundary and priority areas as proposed above.
- incorporate this plan and the amended Esperance Water Reserve boundary, priority areas and wellhead protection zones in the Esperance local planning scheme.
- refer any subdivision and development applications in the Esperance Water Reserve Area that are inconsistent with our Water quality protection note no. 25: *Land use compatibility in public drinking water source areas* or recommendations in our *Esperance Water Reserve drinking water source protection plan* to the Department of Water for advice.

This plan is consistent with the *Australian Drinking Water Guidelines* (NHMRC & NRMMC 2011) and the WA Planning Commission, State planning policy no. 2.7*: Public drinking water source policy.*

This document has been prepared in consultation with stakeholders, including the Water Corporation and the Shire of Esperance.

A summary of information relevant to the Esperance Water Reserve is given below.

Local government authority	Shire of Esperance
Location supplied	Esperance
Aquifer type	Unconfined
Volume of water abstracted	Approximately 2.02 GL abstracted in 2010 Licensed under the *Rights in Water and Irrigation Act 1914* (WA) to abstract 2.7 GL/yr
Number of bores	33
Bore names, GPS coordinates and date of bore completion	See Table 1 in Section 1.1.
Date of previous drinking water source protection plan	September 1999
Proclamation status	First proclaimed in 1970 under the *Country Areas Water Supply Act 1947* (WA). Reproclaimed under this Act in 2001 to encompass amendments to the water reserve boundary. The 2012 drinking water source protection plan proposes changes to the Esperance Water Reserve that will need to be proclaimed.

1 Overview of Esperance's drinking water source

1.1 The drinking water supply system

Esperance is located on the south coast of Western Australia, approximately 600 km south east of Perth. Esperance is a major port and service centre for the surrounding agricultural and inland mining areas. There are approximately 9 918 people in the town of Esperance and around 13 477 within the Shire of Esperance (Australian Bureau of Statistics 2012). The population increases significantly in the summer months due to an influx of tourists.

Esperance's drinking water is supplied from 33 production bores (see Table 1) located within and to the west of the town. These bores draw water from an unconfined aquifer, at depths ranging from around 5.82 m to 55 m. The borefield also contains 15 monitoring bores and five saltwater interface monitoring bores that monitor saltwater movement from Pink Lake and the ocean.

The production bores pump to Thompson Street and Paine Road pumping stations, where the water is treated. Treatment of raw water consists of calgon dosing (to inhibit calcium precipitation), fluoride dosing (to reduce tooth decay) and chlorination (disinfection).

During winter most water is transferred from the pumping stations to two storage tanks at Dempster Head (9000 kL and 15 000 kL). However, in the summer months when demand is greater the tanks may be by-passed and the town supplied directly from the pumping stations.

Raw water quality in a number of bores exceeds values in the Australian Drinking Water Guidelines (NHMRC & NRMMC 2011) for the aesthetic parameters of salinity and turbidity and the health-related parameter of nitrate. The borefield is carefully managed so that bores are selected to produce a blended supply that, once treated, meets the guidelines.

It should be recognised that although treatment and disinfection are essential barriers against contamination, catchment management is the first step in protecting water quality and ensuring a safe drinking water supply. This approach is endorsed within the Australian Drinking Water Guidelines (NHMRC & NRMMC 2011) and reflects a risk-based, multiple-barrier approach for providing safe drinking water to consumers. This combination of catchment protection and water treatment will deliver a more reliable, safer and lower-cost drinking water to consumers than either approach could achieve individually.

Table 1 Production bore details

Bore name	Bore completion date	GPS coordinates		Screened depth m below top of casing
		Easting	Northing	
2 (2A/80)	November 1980	396663	6253013	15.2–21.3
3 (9/00)	June 2000	396350	6252983	13.5–25.5
4 (4A80)	November 1980	396361	6252535	12.2–18.3
5 (11/01)	August 2001 (redrilled)	395995	6252620	13.3–25.0
6 (6A/80)	November 1980	396069	6252954	15.2–21.3
9 (1/91)	January 1991	395124	6252408	12.4–18.3
10 (31/97)	December 1997	394659 5	6252979	12.14–27.2
12 (10/01)	August 2001 (redrilled)	394746	6252685	11.3–23.0
13	1994	394659	6252979	12.5–17.5
15 (1/00)	February 2000	395959	6253164	8.4–20.2
21 (11/00)	July 2000	395287	6252024	26.3–38.3
22 (9/01)	July 2001	394964	6251910	18.2–30.2
23 (23/71/80)	November 1980	394652	6251844	15.9–22.1
24 (10/00)	July 2000	394628	6251613	28.3–70.3
25 (1/83)	March 1983	393828	6252165	18.4–30.8
26 (2/83)	April 1983	393653	6252398	18.2–30.3
27 (3/83)	April 1983	393242	6252231	28.0–31.8
28 (9/83)	April 1983	392880	6252122	6.0–20.53
29 (11/83)	July 2001 (redrilled)	393183	6251867	8.3–23.3
30 (8/83)	April 1983	391934	6251908	9.9–24.6
31 (10/83)	June 2000 (redrilled)	391475	6251509	5.82–17.82
32 (1/85)	March 1985	390888	6251046	15.7–40.0
33 (2/85)	March 1985	390412	6251524	6.0–17.8
34 (3/85)	March 1985	390033	6250969	2.78–25.1
35 (2/88)	March 1988	392515	6251744	8.5–29.8
36 (1/88)	March 1988	391946	6251494	15.4–26.1
37 (1/08)	September 2008 (redrilled)	394676	6252234	12.4–18.4
38 (4/91)	January 1991	394216	6251875	18.5–23.9
39 (5/91)	January 1991	394252	6251388	25.3–31.1
40 (27/97)	November 1997	389062	6249673	29.0–34.7
41 (28/97)	November 1997	388463	6249775	39.0–44.7
42 (32/97)	January 1998	387947	6250114	48.5–57.2
43 (29/97)	December 1997	387753	6250661	55.7–64.7

1.2 Water management

1.2.1 Licence to take water

Water resource use and conservation in Western Australia is administered by the Department of Water in accordance with the *Rights in Water and Irrigation Act 1914*. Under this Act, the right to use and control water is vested with the Crown. This means that a licence is required for drilling bores and abstracting groundwater (pumping water from a bore, spring or soak) within proclaimed groundwater areas throughout the state. An exemption may apply such as abstracting water for domestic purposes only.

The Esperance Groundwater Area was proclaimed in 1973 under the *Rights in Water and Irrigation Act 1914* (WA). Production bores for the town's water supply are located within three subareas of the Esperance Groundwater Area: Town, Twilight and Butty. The Water Corporation holds three groundwater licences for the Esperance town water supply scheme for a total of 2.7 GL per year. Abstraction in 2010 (total of around 2.02 GL) was lower than the allocated amount (see Table 2).

Table 2 Allocation licence and abstraction information

Licence number	Subarea	Allocation limit GL/yr	Abstraction in 2010 GL
GWL 64306	Town	1.15	0.93
GWL 156783	Twilight	0.60	0.45
GWL 156785	Butty	0.95	0.64

1.2.2 Water planning

In 2007, the Department of Water published the *Esperance Groundwater Area water management plan*. This plan provides guidance on the management of groundwater resources in the Esperance Groundwater Area. Within the Esperance Groundwater Area the department aims to achieve sustainable water allocation and development for current and future uses while ensuring groundwater-dependent ecosystems are maintained. The plan provides objectives, policies, principles and strategies to meet these aims. Allocation limits for each of the subareas are also provided in the plan.

1.2.3 Future water needs

The allocation limits set in the *Esperance groundwater area water management plan* are sufficient to cater for the predicted future demand in this area. At present there are no over-allocated resources. The Town and Twilight subareas are approaching their allocation limits. The Butty subarea provides the best option to meet future public water supply needs over the longer term.

The department is conducting investigations into the groundwater resources in the Esperance groundwater area and the allocation limits are unlikely to change in the short term until these investigations are completed.

Any changes to the management of the borefield are likely to require further investigation, particularly if water quality changes. Additional monitoring to minimise the impacts of abstraction is also likely.

In August 2011, Esperance was one of nine regional towns chosen to be part of the new 'SuperTowns' initiative. The initiative assists towns in developing plans for growth and provides funding and support to develop infrastructure to attract new businesses and investment. The program is designed to result in an attractive alternative living location to the Perth metropolitan area to deal with the predicted population increases in Western Australia.

1.3 Characteristics of the catchment

1.3.1 Physical environment

The southern coastline of the Esperance area consists of rocky headlands with intervening stretches of sandy beaches. Coastal dunes, ranging in height from 10 m AHD to more than 100 m AHD, extend west from Esperance to Lake Gore.

The Esperance Water Reserve is located on the Coastal Plain, which extends up to 10 km inland from near the coast. To the north of the water reserve are a series of brackish to saline lakes, including Pink Lake, Lake Mortijinup and Lake Gore.

1.3.2 Climate

Esperance has a Mediterranean-type climate, with cool, wet winters and warm to hot, dry summers. Since 1969, the average monthly maximum temperatures range from 17.1 ^{o}C in July to 26.2 ^{o}C in February and the average monthly minimum temperatures range from 8.3 ^{o}C in July to 16.1 ^{o}C in February (Bureau of Meteorology 2012). Average annual rainfall (since 1969) is 616.3 mm, with most occurring during the winter months (Bureau of Meteorology 2012).

1.3.3 Hydrogeology

The geology and hydrogeology of the Esperance area is described in detail in Water Corporation (1998) *Esperance source investigation report: 1997 drilling program and resource assessment* and Water and Rivers Commission (1998) *Hydrogeology of the Esperance-Mondrain Island.* Information from these reports is summarised below.

The area is underlain by weathered granite basement rocks deposited in the Proterozoic era. These are unconformably overlain by formations of the Plantagenet Group: the Werillup Formation and Pallinup Siltstone, which were deposited in the Middle to Late Eocene. Quaternary sediments unconformably overlie the Plantagenet Group near the coast, forming dune deposits of sand and calcareous arenite limestone.

Aquifers exist within each of these formations; however, their potential yields and salinities vary considerably. The Quaternary sediments contain the principle freshwater aquifer within the region and production bores for the town's water supply draw from this aquifer. Salinity within the Quaternary aquifer is generally less than 1000 mg/L.

South of Pink Lake, the base of the Quaternary contains saline groundwater overlain by around 25 m of freshwater. There is potential in this area for abstraction from production bores to result in upconing of the saline groundwater and an increase in salinity in bores within this area (Crisalis International Pty Ltd 2011).

The Quaternary aquifer is unconfined and recharged primarily by rainfall, and is vulnerable to contamination from overlying land uses. Recharge levels have been estimated to range from around 10 to 50 per cent but vary according to a range of factors such as vegetation cover. Greatest levels of recharge occur in areas of mobile dunes bare of vegetation and lowest levels of recharge occur in the areas with a shallow watertable such as adjacent to wetlands.

A groundwater mound has formed between the coastline and Pink Lake, due to increased recharge within this area. Groundwater levels are over 30 m AHD west of Pink Lake, but depressed to below 0 m AHD on the western margin of the town due to groundwater abstraction. Pre-pumping levels in the area are thought to be around 3 m AHD. Groundwater flow within the area of the borefield is dominated by radial flow away from the crest of the mound towards the ocean and coastal lake discharge boundaries.

1.4 How is the drinking water protected?

The Esperance Water Reserve was first proclaimed in 1970 under the *Country Areas Water Supply Act 1947* (WA), and reproclaimed in 2001 to encompass amendments to the boundary of the water reserve, as a result of new information in the 1999 *Esperance Water Reserve water source protection plan*. Proclamation identifies the location of the water reserve and ensures that its drinking water value is considered in land use planning decisions. It also allows by-laws to be applied for the protection of water quality.

In 1999, the *Esperance Water Reserve water source protection plan* was prepared. The plan:

- provided information on the borefield
- identified risks to the drinking water supply
- recommended strategies to manage these risks
- assigned priority areas for the management of the reserve
- proposed amendments to the water reserve boundary.

Fourteen key recommendations were made in the 1999 plan, two of which are no longer applicable. Eight of these recommendations have been carried out and three are ongoing. Implementation of the remaining recommendation to support the Department of Environment and Conservation initiative to include vacant Crown land

into the Butty Harbour Nature Reserve, subject to recognition of public water supply requirements, has begun. These recommendations and their implementation status are shown in Table 3.

This document replaces the 1999 plan, as it provides more up to date information.

The *Shire of Esperance Local Planning Scheme No. 23* (Shire of Esperance 2010) recognises the Esperance Water Reserve as a special control area. Provisions for this special control area note that 'Despite any other provision of the Scheme planning approval is required for all use and development including a single house, removal of vegetation, earthworks or the use of land for the keeping of or grazing of animals'.

In making decisions on development applications the shire has regard to drinking water source protection requirements and advice, such as the requirements of:

- WA Planning Commission, State planning policy no. 2.7*: Public drinking water source policy*
- Department of Water, Water quality protection note no. 25*: Land use compatibility in public drinking water source areas*
- any advice received from the Department of Water.

The Water Corporation regularly patrols and surveys the water reserve to identify risks to water quality and enforce the by-laws where required. This plan recommends formally delegating catchment management powers to the Water Corporation.

Table 3 Status of recommendations from the 1999 protection plan

No.	Description	Status	Additional information
1	Gazettal of amendments to the water reserve	Complete	Amendments gazetted in 2001 under the *Country Areas Water Supply Act 1947* (WA).
2	Incorporation of the water reserve into relevant planning strategies	Complete	The water reserve has been incorporated in the *Shire of Esperance Local Planning Scheme No. 23* as a special control area.
3	Referral of development proposals to Department of Water (formerly Water Resources Commission)	Ongoing	The Shire of Esperance refers proposals to the Department of Water's South Coast regional office.
4	Erection of signs	Complete	Signs were erected in 2002 and 2011. Note: additional signage may be required.
5	Preparation and distribution of educational material about pollution prevention	Complete	Information was distributed in 2001.
6	Ensuring emergency response personnel are aware of the location and purpose of the reserve	Complete	Maps were sent to FESA and the police in 1999 and 2000.

No.	Description	Status	Additional information
7	Initiate a surveillance program	Ongoing	Water Corporation undertakes surveillance.
8	Review the groundwater quality monitoring program	Ongoing	Groundwater quality monitoring program is undertaken by the Water Corporation and regularly reviewed by Department of Water and the Water Corporation through the Water Corporation's licence and operating strategy.
9	Incorporation of clauses in the shire's local planning scheme to prevent overstocking of rural land within the water reserve	Complete	Esperance local planning scheme requires approval from the Shire of Esperance for animal grazing within the water reserve. It also includes restrictions on the keeping of horses in the rural residential area south of Eleven Mile Beach Road (RR2).
10	Assessment of Pink Lake Road service station's underground storage tanks and hydrocarbon waste disposal systems	Complete	Investigated in 2001. Service station has now closed.
11	Investigation of storage and disposal of chemicals at the Pink Lake Road dry cleaning business	Not applicable	Dry cleaning business closed.
12	Negotiate upgrades to pollution control facilities with Western Power as necessary	Not applicable	Due to decommissioning of bore 16 the site is no longer within the water reserve. Western Power has undertaken remedial actions.
13	Close production well 16	Complete	Bore decommissioned in July 2001.
14	Support Department of Environment and Conservation (DEC) initiative to include vacant Crown land into the Butty Harbour Nature Reserve, subject to recognition of public water supply requirements	Commenced	Discussions occurred with DEC in 2001 and 2010. DEC's *Management plan for Esperance Coastal Reserves – Issues paper* recommends that Crown reserve 30672 be incorporated into their conservation estate and part of Crown reserve 24486 be incorporated into the Lake Mortijinup Nature Reserve. However, further negotiations were still required with Water Corporation. The remainder of Crown land within the water reserve was noted as not being suitable for addition into their conservation estate.

1.5 Other useful information

1.5.1 Other groundwater bores in the area

The Water Corporation operates drinking water bores in the Esperance Water Reserve. If bores for other purposes (e.g. irrigation, private household use) are drilled near a public drinking water supply bore, they can cause contamination of the drinking water source. For example, a poorly constructed private bore may introduce contaminants from surface leakage down the outside of the bore casing into an otherwise uncontaminated aquifer.

It is therefore important to ensure that any bores are appropriately located and constructed to prevent contamination of the public drinking water source. This will be assessed through the Department of Water's water licensing process where applicable under the *Rights in Water and Irrigation Act 1914*. All bores should be constructed in accordance with *Minimum construction requirements for water bores in Australia* (National Minimum Bore Specifications Committee 2003).

2 Common contamination risks

Land development and land- and water-based activities within a water reserve can directly affect the quality of the drinking water and its treatment. Contaminants can reach drinking water sources through run-off over the ground and infiltration through soil. A wide range of microbiological, chemical and physical contamination risks can impact on water quality and therefore affect the provision of safe, good quality drinking water to consumers.

Some contaminants in drinking water can affect human health. Other impurities can affect the water's aesthetic qualities, including its appearance, taste, smell and 'feel' but are not necessarily hazardous to human health. For example, cloudy water with a distinctive odour or strong taste may not be harmful to health, but clear, pleasant-tasting water may contain harmful, undetectable microorganisms (NHMRC & NRMMC 2011). Contaminants can also interfere with water treatment processes, and damage water supply infrastructure (such as iron corroding pipes).

The *Australian Drinking Water Guidelines* (ADWG) outline criteria for drinking water of acceptable quality to protect human health, manage aesthetics and maintain water supply infrastructure.

For more information about water quality in this drinking water source, see section 3.

Some commonly seen contamination risks relevant to groundwater drinking water sources are described below.

2.1 Microbiological

Pathogens are types of microorganisms that are capable of causing illness. These include bacteria, protozoa and viruses. In drinking water supplies, pathogens are commonly found in the faeces of humans and domestic animals (such as dogs and cattle).

Pathogens can enter drinking water supplies from faecal contamination in the water reserve. In groundwater sources, this occurs indirectly – faecal material can infiltrate through the soil and into the groundwater. For example, contamination can occur from septic tanks or grazing animals.

A number of pathogens are commonly known to contaminate water supplies worldwide. These include bacteria (e.g. salmonella, *Escherichia coli* and cholera), protozoa (e.g. *Cryptosporidium*, *Giardia*) and viruses. *E. coli* counts provide an indication of the level of faecal contamination.

Pathogen contamination of a drinking water source is influenced by many factors including the existence of pathogen carriers (e.g. humans and domestic animals), the transfer to and movement of the pathogen in the water source and its ability to survive in the water. The percentage of humans in the world that carry pathogens varies. For example, it is estimated that between 0.6 and 4.3 per cent of people are infected with *Cryptosporidium* worldwide, and 7.4 per cent with *Giardia* (Geldreich 1996).

The survival and movement of pathogens in groundwater is influenced by the characteristics of the pathogen (such as its size and the length of time it normally takes to decay) and the groundwater properties (including flow rate, porosity, amount of carbon in the soil, temperature, pH). Inactivation rate (the time it normally takes a pathogen to decay) is one of the most important factors governing how far pathogens may migrate. Typical half-lives of pathogens range from a few hours to a few weeks. For example, maximum reported migration distances of bacteria in groundwater are:

- 600 m in a sandy aquifer
- 1 000 – 1 600 m in channelled limestone
- 250 – 408 m in glacial silt-sand aquifers (Robertson & Edbery 1997).

Therefore it is important to understand the groundwater system to be able to protect the drinking water source from pathogens.

When people consume drinking water contaminated with pathogens the effects vary considerably, ranging from mild illness (such as stomach upset or diarrhoea) to hospitalisation and sometimes even death. During 2000, seven people died in Walkerton, Canada, because the town's water supply was contaminated by a pathogenic strain of *E. coli* and campylobacter (NHMRC & NRMMC 2011).

Where possible, avoiding the introduction of pathogens into a water source is the most effective way to protect public health.

2.2 Physical risks

Turbidity is the result of soil or organic particles becoming suspended in water (cloudiness). Increased turbidity can result in cloudy or muddy-looking water, which is not very appealing to consumers. Turbidity can also reduce the effectiveness of treatment processes (such as disinfection). This is because pathogens can adsorb onto soil particles and may be shielded from the effects of disinfection. Chemicals can also attach to suspended soil particles.

Some physical properties of water such as pH (a measure of acidity or alkalinity) can contribute to the corrosion and encrustation of pipes. Other properties such as iron and dissolved organic matter can affect the colour and smell of water. Although not necessarily harmful to human health, coloured or 'hard' water will not be as appealing to consumers. Salinity can affect the taste of drinking water.

2.3 Chemical risks

Chemicals can occur in drinking water as a result of natural leaching from mineral deposits or from different land uses (NHMRC & NRMMC 2011). A number of these chemicals (organic and inorganic) are potentially toxic to humans.

Pesticides include agricultural chemicals such as insecticides, herbicides, nematicides (used to control worms), rodenticides and miticides (used to control mites). Contamination of a drinking water source by pesticides (and other chemicals) may occur as a result of accidental spills, incorrect use or leakage from storage

areas. In these cases, the relevant authorities should be notified promptly and the spill cleaned up to prevent contamination of the drinking water source.

Hydrocarbons (e.g. fuels, oils) are potentially toxic to humans, and harmful chemical by-products may be formed when they are combined with chlorine during the water-treatment process. Hydrocarbons can occur in water supplies as a result of spills and leakage from vehicles.

Drinking water sources can also be contaminated by nutrients (such as nitrogen) from fertiliser applications, faulty septic systems, leach drains and from domestic and feral animal faecal matter that washes through or over soil and into a water source. Nitrate and nitrite (forms of nitrogen) can be toxic to humans at high levels, with infants younger than three months being most susceptible (NHMRC & NRMMC 2011).

Other chemicals and heavy metals can be associated with land uses such as industry and landfill. These may enter drinking water sources and could potentially be harmful to human health.

3 Contamination risks in this drinking water source

3.1 Water quality

The Water Corporation regularly monitors the quality of raw water from the Esperance borefield for microbiological, health-related and aesthetic (non-health-related) characteristics. This data shows the quality of water in the water reserve. An assessment of the drinking water quality once treated is also made against the ADWG. This assessment is made by an intergovernmental committee called the Advisory Committee for the Purity of Water that is chaired by the Department of Health.

Raw water quality issues within the Esperance borefield include:

- increased salinity in some bores due to upconing of more saline water during pumping
- elevated nitrates within some bores. These levels have generally been falling since the early to mid 1990s as a result of the provision of deep sewerage in the mid to late 1980s; however, a few bores have shown an increase in nitrate concentrations.
- elevated hardness
- high turbidity and iron in some bores
- low level detections of atrazine in some bores within the urban area
- low level microbiological detections.

It should be noted that once water from the different bores is blended and treated, the drinking water supplied to Esperance meets the ADWG.

A water quality summary for the Esperance borefield from October 2006 to October 2011 is presented in Appendix B. For more information on water quality, see the Water Corporation's most recent drinking water quality annual report at <www.watercorporation.com.au> What we do > Water quality > Water quality publications > Click on the most recent *Water quality annual report*.

3.2 Land uses and activities

The Esperance Water Reserve is located over a mixture of Crown and privately owned land. Current land uses and activities and their risks to the drinking water source are described below and shown in Figures A4, A5, A6 and A7. Table 4, at the end of this section, summarises this information in an easy-to-read format. Appendix C displays a more detailed risk assessment, and includes recommended protection strategies to address water quality risks.

3.2.1 Urban

There is urban development in the eastern part of the water reserve. A number of shallow production bores draw water from within the urban area (see Figures D1, D3 and D5). The area is dominated by residential housing, but also includes some commercial premises on Pink Lake Road: schools, irrigated parks and ovals, a public swimming pool and a cemetery (see Figure A7).

A service station used to be located on Pink Lake Road; however, it has since closed and the site has been redeveloped into a supermarket. The post closure management of the site is unknown. To ensure that no hydrocarbon contamination has occurred the site could be assessed under the *Contaminated Sites Act*. This site is not currently registered as a contaminated site.

Most of the residential and commercial development was connected to deep sewerage in the mid to late 1980s. However, a few residential areas and a primary school still utilise on-site wastewater disposal systems.

Risks to the water source from urban development include nutrient contamination from fertiliser use and on-site wastewater disposal, pathogen contamination from on-site wastewater disposal and domestic animals, hydrocarbon contamination from oil and fuel leaks and spills and chemical contamination from pesticide and household chemical use.

The Shire of Esperance is responsible for the management of weeds on the sporting ovals and verges in the area. The shire uses best management practices and only applies herbicides as described in the Department of Health *Circular no: PSC 88: Use of herbicides in water catchment areas*.

3.2.2 Rural residential

There are significant areas of rural residential development immediately to the west of the townsite (see Figure D2). These lots range in size from approximately 2 ha to 8 ha. Houses are serviced by on-site wastewater treatment systems. Horses and other stock are grazed on some lots.

Controls within the *Shire of Esperance Local Planning Scheme No. 23* include:

- A two metre separation is required between the base of a leach drain and the highest recorded groundwater level.
- Development of a house, removal of vegetation, earthworks and animal grazing within the water reserve requires approval from the shire.
- Prohibition of keeping horses on lots less than 4 ha and restriction of a maximum of two horses on lots greater than 4 ha within the rural residential area south of Eleven Mile Beach Road (RR2).

Risks to the water source from rural residential areas include pathogen and nutrient contamination from on-site wastewater disposal and animals, and nutrient and chemical contamination from fertiliser and pesticide use and hydrocarbon contamination from oil and fuel leaks and spills.

3.2.3 Rural

There is one large vegetated rural lot on the very western end of the water reserve. Risks to the water source from this lot are considered low due to the distance from the bores. Dryland agriculture occurs on this rural lot.

3.2.4 Crown land

The western portion of the water reserve is mostly vegetated Crown land (see Figures A6 and A8), and includes:

- A rifle range (most of Crown reserve 15042).
- The Ten Mile Lagoon and Nine Mile Beach wind farms (Crown reserve 44701).
- Crown reserve 192329, which is the site of the Salmon Beach Wind Farm. The wind farm operated from 1987 until 2002, when it was decommissioned. The reserve is now vested in the Shire of Esperance for conservation and recreation purposes.
- An off-road vehicle area vested in the Shire of Esperance (Crown reserve 34777).
- Crown reserve 4180, which is vested in Shire of Esperance and contains a number of the production bores.
- Crown reserve 24486, a large reserve that is currently unvested. Three production bores are located in the eastern portion of this reserve. The Department of Environment and Conservation's *Management plan for Esperance coastal reserves – Issues paper,* recommends that the western part of this reserve be incorporated into the Lake Mortijinup Nature Reserve. However, further negotiations are still required with Water Corporation.
- Crown reserve 30672, which is currently unvested. The reserve includes a day-use recreation site, with a vista point and access for fishing and wildlife viewing. The *Management plan for Esperance coastal reserves – Issues paper,* recommends that this reserve be considered for addition as a nature reserve.
- Crown reserve 4182, vested with DEC for conservation purposes.

Contamination risks from the above mentioned activities on Crown land include the potential for fuel spills and leaks from motorbike and four-wheel drive vehicle access around the borefield and off-road vehicle area (see Figure A6), rubbish dumping within the borefield, heavy metal contamination from spent shots at the rifle range and pathogens from human and animal access.

3.2.5 Other

Other land uses within the water reserve include:

- A quarry and proposed sand mine. Risks to the water source from extractive industry include fuel and oil leaks and spills. The risks are minimised by development conditions imposed by the Shire of Esperance and the Department of Mines and Petroleum.

- Roads and railways. Risks to the water source include hydrocarbon contamination from accidents and chemical contamination from the use of pesticides on road and railway verges.

3.2.6 Aboriginal sites of significance and Native title claims

Aboriginal sites of significance are those areas that Aboriginal people value as important and significant to their cultural heritage. The sites are significant because they link Aboriginal culture and tradition to place, land and people over time. These areas form an integral part of Aboriginal identity and the heritage of Western Australia. The *Aboriginal Heritage Act 1972* (WA) protects all Aboriginal sites in the state.

There are two Aboriginal sites of significance within the Esperance Water Reserve. These are Pink Lake waterhole and Twilight Cove midden (WO1098).

Native title is the recognition in Australian law that some Aboriginal people continue to hold Native title rights to lands and water arising from their traditional laws and customs.

Within Esperance Water Reserve an application for native title has been registered for The Esperance Nyungars (WAD6097/98).

The Department of Water is committed to working with Aboriginal people in its planning and management activities. The department recognises that Native title provides an important framework for water management.

3.3 Possible future contamination risks

To the north of the urban area, in the eastern portion of the water reserve, there are areas zoned for future residential and future industrial and commercial development. In addition there are a number of lots along and just to the north of Twilight Beach Road that are zoned residential, but have not yet been subdivided. Risks to the water source from urban development are described in Section 3.2.1 above.

Industrial development can introduce additional risks from the storage and use of chemicals and hydrocarbons. All future urban development should be connected to deep sewers and be in accordance with the recommendations of Water quality protection note no. 25*: Land use compatibility in public drinking water source areas* (Department of Water 2004).

Table 4 Land use and potential water quality risks

Land use/activity	**Hazard/s**	**Management priority**	**Compatibility of land use/activity**	**Best management practice guidance [2]**
Urban				
Urban development (sewered)	• nutrients • chemicals • hydrocarbons • pathogens	Medium	Acceptable in P3 areas	• *Living and working in PDWSAs* • *FertiliseWISE – protect and maintain our local water supplies* • WQPN no. 70: *Wastewater treatment and disposal- domestic systems* • Environmental health guide*: Understanding septic tank systems*
Urban development (unsewered)	• nutrients • chemicals • hydrocarbons • pathogens	High	Incompatible in P3 areas[1]	
Cemetery	• nutrients • chemicals	Low	Compatible with conditions in P3 areas	• *Environmental guidelines for the establishment and maintenance of turf and grassed areas* • Circular no: PSC 88: *Use of herbicides in water catchment areas*
Parks and ovals	• nutrients • chemicals	Medium	Compatible with conditions in P3 areas	
Former service station	• hydrocarbons • heavy metals	Low	Not applicable	

[1] Note: existing, approved incompatible land uses are able to continue, with best management practices encouraged.

[2] For brevity, the full details of these water quality protection notes (WQPNs) and water quality protection guidelines (WQPG's) are provided in the references list.

Land use/activity	Hazard/s	Management priority	Compatibility of land use/activity	Best management practice guidance [2]
Rural residential				
Rural residential	• nutrients • chemicals • pathogens • hydrocarbons	Medium	Subdivision to 2 ha or greater is compatible with conditions in P2 areas zoned as rural residential	• WQPN no. 70: *Wastewater treatment and disposal- domestic systems* • Environmental health guide: *Understanding septic tank systems* • WQPG no. 13*: Environmental guidelines for horse facilities and activities*
Crown land				
Rifle range	• heavy metals • nutrients	Low	Incompatible in P1 areas[1]	• Statewide policy no.13: *Recreation within public drinking water source areas on Crown land* • Department of Environment and Conservation Policy Statement no. 18: *Recreation, tourism and visitor services*
Off-road vehicle use	• hydrocarbons	Low	Acceptable within designated areas. Unacceptable outside designated areas.	
Other				
Extractive industry • sand mining • quarry	• hydrocarbons	Low	Compatible with conditions in P1 and P2 areas	• WQPN no. 15: *Extractive industries near sensitive water resources* • Statewide policy no. 1: *Policy and guidelines for construction and silica sand mining in public drinking water source areas*

Land use/activity	**Hazard/s**	**Management priority**	**Compatibility of land use/activity**	**Best management practice guidance [2]**
Roads and railways	• chemicals • hydrocarbons	Medium	Compatible with conditions in P2 and P3 areas	• WQPN no. 10: *Contaminant spills – emergency response* • WQPN no. 44: *Roads near sensitive water resources* • WQPN no. 83: *Infrastructure corridors near sensitive water resources*
Potential future land uses				
Future urban • industrial • commercial • residential	• nutrients • chemicals • hydrocarbons • pathogens • heavy metals	Medium	Residential and commercial development is acceptable in P3 areas (if connected to deep sewer). Light industry and some general industry is compatible with conditions. Heavy industry is incompatible.	• WQPN no. 13: *Dewatering of soils at construction sites* • WQPN no. 20: *General and heavy industry* • WQPN no. 93: *Light industry near sensitive waters*

Water quality protection notes are available <www.water.wa.gov.au> Publications> Find a publication> Series browse> Water quality protection notes

4 Protecting your drinking water source

The objective of this plan is to preserve water quality at its current level, and where practical achieve an improvement so as to ensure the continued supply of safe drinking water to Esperance.

4.1 Groundwater flow modelling

The Department of Water commissioned Crisalis International Pty Ltd to develop a groundwater flow model for the aquifer system. A numerical model was developed using a modelling package. The model was calibrated for both steady state and transient conditions. Particle tracking simulation was used to delineate production bore capture zones, flow path lengths and travel times. Details of the modelling methodology and results are provided in Crisalis International Pty Ltd (2010 and 2011).

The results of this modelling have been used to assess the current boundary of the water reserve.

4.2 Proclaiming the public drinking water source area

The proclamation process begins with public consultation as part of the development of the drinking water source protection plan.

The current boundary of the Esperance Water Reserve was proclaimed under the *Country Areas Water Supply Act 1947* (WA) in 2001.

This plan recommends that based on modelling of Esperance groundwater flows, two sections be removed from the water reserve. The current water reserve boundary and proposed new boundary are shown in Figures A2 and A3.

The plan recommends the removal of a wedge of land directly south-east of Pink Lake, extending south-east along Pink Lake Road and reaching as far east as Garden Road in the north part of the wedge. This area contains the Pink Lake Country Club Golf Course, a number of private blocks surrounding the golf course and a disused landfill site (see Figure A3).

The plan also recommends the removal of a section of land which is currently a mix of P2 and P3. The section covers all of the P3 coastal area adjacent to Twilight Beach Road and the P2 coastal area that extends from Twilight Beach Road south to the coastline (see Figures A2 and A3).

Changes to the water reserve boundary and priority areas have only been made in the Eastern section of the Esperance Water Reserve as shown in Figure A10.

Once the water reserve is amended the local government authority is expected to incorporate the amended public drinking water source area into their planning schemes consistent with the WA Planning Commission State planning policy no. 2.7*: Public drinking water source policy*. Public drinking water source areas are commonly

shown in planning schemes as special control areas. This provides guidance for state and local government planning decision makers and land developers.

Proclamation of a PDWSA does not change the zoning of any land. All existing, approved land uses and activities in a proclaimed area can continue. However, we recommend that best management practices are employed in PDWSAs to protect the quality of the drinking water source. There is no current requirement to obtain any licences to operate any differently within a proclaimed PDWSA. The assignment of priority areas to guide land use planning does not change zoning of the land either.

New developments or expansion of existing land uses or activities need to consider the recommendations in this plan.

4.3 Defining priority areas

The protection of PDWSAs relies on statutory and non-statutory measures for water resource management and land-use planning. The Department of Water's policy for the protection of PDWSAs includes a system that defines three specific priority areas:

- Priority 1 (P1) areas have the fundamental water quality objective of risk avoidance (e.g. state forest and other Crown land).
- Priority 2 (P2) areas have the fundamental water quality objective of risk minimisation (e.g. land that is zoned rural).
- Priority 3 (P3) areas have the fundamental water quality objective of risk management (e.g. areas zoned urban or light/general industrial).

The determination of priority areas is based on the strategic importance of the land or water source including risks to water quality and quantity, the local planning-scheme zoning, the form of land tenure and existing approved land uses or activities. For further detail, please refer to our WQPN no. 25: *Land use compatibility in public drinking water source areas*.

The priority areas for the Esperance Water Reserve have been determined in accordance with current Department of Water policy. These areas are described below and displayed in Figures A8 and A9. Our WQPN no. 25: *Land use compatibility in public drinking water source areas* outlines activities that are 'acceptable', 'compatible with conditions' or 'incompatible' within the different priority areas. For an explanation of the background and support for protection of PDWSAs, please refer to WQPN no. 36: *Protecting public drinking water source areas*.

There is a section of P2 land that extends west from Peek Street and Stewart Street that will be changed to a P1 area to reflect the zoning of the area as Crown reserve (see Figure A9). North of this section, on the northern boundary of the existing P1 area and south of Thompson Street, there is another P2 section of vegetated land that will also be changed to P1 to reflect the zoning of the area as Unallocated Crown land. We propose to retain all of the existing P1 land (including Water Corporation land and all Crown land) in the Esperance water reserve as P1 because:

- water from this source is the only supply available to Esperance
- current land uses on the Water Corporation and Crown land are considered 'acceptable' in P1.

There is no additional land that will be changed to P2. The P2 land is based on (see Figure A9):

- current land use being 'compatible with conditions' provided best management practices are applied
- the land being privately owned and zoned rural.

There are two sections of P2 land that will be assigned P3 to reflect their zoning (see Figure A9). Existing P3 areas will to remain as P3 because:

- existing land uses are considered 'compatible with conditions' provided best management practices are applied
- the land is privately owned and zoned as residential or industrial.

4.4 Defining protection zones

In addition to priority areas, protection zones are defined to protect drinking water sources from contamination in the immediate vicinity of water extraction facilities. Specific conditions may apply within these zones such as restrictions on the storage of chemicals or public access.

There are 33 production bores in the Esperance Water Reserve and each bore is protected by a Wellhead protection zone.

Wellhead protection zones (WHPZs) are generally circular (unless information is available to determine a different shape or size), with a 500 m radius around each production bore in a P1 area and a 300 m radius around each production bore in P2 and P3 areas. WHPZs do not extend outside the boundary of the water reserve.

Where the WHPZ extends over a combination of these different priority areas (e.g. P1 and P2) the WHPZ will extend the respective lengths into the different priority areas. Please see Figure A9 for the location and size of the WHPZs within the Esperance Water Reserve.

4.5 Planning for future land uses

It is recognised under the Western Australian Planning Commission's (WAPC) *State planning strategy* (1997) that appropriate protection mechanisms in statutory land-use planning processes are necessary to secure the long-term protection of drinking

water sources. As outlined in the WAPC's Statement of planning policy no. 2.7: *Public drinking water source policy* (2003) it is appropriate that the Esperance Water Reserve, its priority areas and protection zones be recognised in the Shire of Esperance local planning scheme. The existing special control area within the Shire of Esperance's local planning scheme should be updated to reflect amendments to the boundary and priority areas in this plan. Any development proposals within the Esperance Water Reserve that are inconsistent with advice in our WQPN no. 25: *Land use compatibility in public drinking water source areas* or recommendations in this plan, need to be referred to the Department of Water for advice.

For further information on the integration of land-use planning and water source protection, please refer to our WQPN no. 36: *Protecting public drinking water source areas*. This protection note describes the findings of Parliamentary Committee reviews instrumental in the integration of water quality protection and land use planning in Western Australia.

The department's protection strategy for PDWSAs provides for already approved developments to continue even if those facilities would not be supported under current water quality protection criteria. In these instances, the department can provide advice to landowners or operators on measures they can use to improve their facilities and reduce water quality contamination risks (see Section 4.6: *Using best management practices*).

4.6 Using best management practices

There are opportunities to reduce water contamination risks by carefully considering design and management practices. To help protect water sources, the Department of Water will continue to encourage the adoption of best management practices.

Guidelines on best management practices for many land uses are available in the form of industry codes of practice, environmental guidelines and water quality protection notes. These outline the recommended practices to ensure the protection of water quality and can thus help managers reduce any detrimental effects of their operations. These guidelines have been developed in consultation with stakeholders such as industry groups, agricultural producers, state government agencies and technical advisers. Examples include:

- WQPN no. 54: *Rezoning and subdivision of land in public drinking water source areas*
- WQPN no. 10: *Contaminant spills - emergency response*
- *Environmental guidelines for the establishment and maintenance of turf and grassed areas*
- WQPN no. 70: *Wastewater treatment – domestic systems*
- WQPN no. 13: *Dewatering of soils at construction sites*
- WQPN no. 15: *Extractive industries near sensitive water resources*
- WQPN no. 44: *Roads near sensitive water resources.*

Education and awareness-raising (such as providing information on signs and in publications) are key mechanisms for protecting water quality, especially for people visiting the area. We will produce a brochure once this plan is finalised describing the Esperance Water Reserve, its location and the main threats to its water quality. The brochure will inform people in simple terms about the drinking water source and why it is important that it be protected. We will make the brochure available to the community and other stakeholders.

4.7 Enforcing by-laws and surveying the area

The quality of water in PDWSAs within country areas of the state is protected under the *Country Areas Water Supply Act 1947* (WA). Proclamation of PDWSAs allows by-laws to be applied to protect water quality.

The Department of Water considers by-law enforcement, through surveillance of land-use activities in PDWSAs, to be an important mechanism to protect water quality.

Additional signs could be erected within the water reserve to continue to educate and advise the public about activities that are prohibited or regulated.

This plan recommends that surveillance and by-law enforcement for the Esperance Water Reserve be formally delegated to the Water Corporation, who regularly patrol the area and undertake water quality monitoring.

4.8 Responding to emergencies

The escape of contaminants during unforeseen incidents and the use of chemicals during emergency responses can result in water contamination. The Shire of Esperance local emergency management committee (LEMC), through the Goldfields-Esperance emergency management district, should be familiar with the location and purpose of the Esperance Water Reserve.

A locality plan will be provided to the fire and rescue services headquarters for the hazardous materials (HAZMAT) emergency advisory team. The Department of Water and the Water Corporation should have an advisory role to the HAZMAT team for incidents in the Esperance Water Reserve.

Personnel who deal with WESTPLAN–HAZMAT (Western Australian plan for hazardous materials) incidents within the area should have access to a map of the Esperance Water Reserve. These personnel should have an adequate understanding of the potential impacts of spills on this drinking water source.

4.9 Putting this plan into action

Table 4 (found at the end of Section 3) identifies the potential water quality risks associated with existing land uses in the Esperance Water Reserve. Further information and the recommended protection strategies to deal with those risks are outlined in Appendix C.

When the final *Esperance Water Reserve drinking water source protection plan* is complete, an implementation strategy will be drawn up based on the recommendations in Appendix C.

5 Recommendations

The following recommendations apply to the entire Esperance Water Reserve. The bracketed stakeholders are those expected to have a responsibility for, or an interest in, implementation of that recommendation.

1. Amend the boundary of the Esperance Water Reserve under the *Country Areas Water Supply Act 1947* (WA) consistent with information in this plan (As shown in Figure A8). (Department of Water)
2. Develop an implementation strategy for this plan's recommendations (including the recommended protection strategies as detailed in Appendix C) showing responsible stakeholders and planned timeframes. (Department of Water, applicable stakeholders)
3. Incorporate this plan and reflect the updated Esperance Water Reserve boundary, Priority 1, 2 and 3 areas and protection zones in the Esperance local planning scheme in accordance with the WAPC's Statement of planning policy no. 2.7*: Public drinking water source policy*. (Shire of Esperance)
4. All development proposals within the Esperance Water Reserve that are inconsistent with the Department of Water's Water quality protection note no. 25*: Land use compatibility in public drinking water source areas* or recommendations in this plan should be referred to the Department of Water for advice and recommendations. (Department of Planning, Shire of Esperance, proponents of proposals)
5. Incidents covered by WESTPLAN–HAZMAT in the Esperance Water Reserve should be addressed by ensuring that:
    a. the Goldfields-Esperance LEMC is aware of the location and purpose of the Esperance Water Reserve
    b. the locality plan for the Esperance Water Reserve is provided to the FESA headquarters for the HAZMAT emergency advisory team
    c. the Department of Water and Water Corporation acts in an advisory role during incidents in the Esperance Water Reserve
    d. personnel dealing with WESTPLAN–HAZMAT incidents in the area have ready access to a locality map of the Esperance Water Reserve and information to help them recognise the potential impacts of spills on drinking water quality. (Department of Water)
6. Formally delegate by-law enforcement and surveillance to the Water Corporation. (Department of Water, Water Corporation)
7. Remove and relocate the water reserve signage on the corner of Pink Lake Road and Eleven Mile Beach Road as the area is proposed to be removed from the water reserve. (Department of Water, Water Corporation)
8. Update this plan after five years. This update may require development of a new protection plan (if substantial changes have occurred) or could be dealt with through the development of a drinking water source protection review (that is to be read alongside this protection plan), if only minor changes are being considered. (Department of Water)

Appendices

Appendix A — Figures

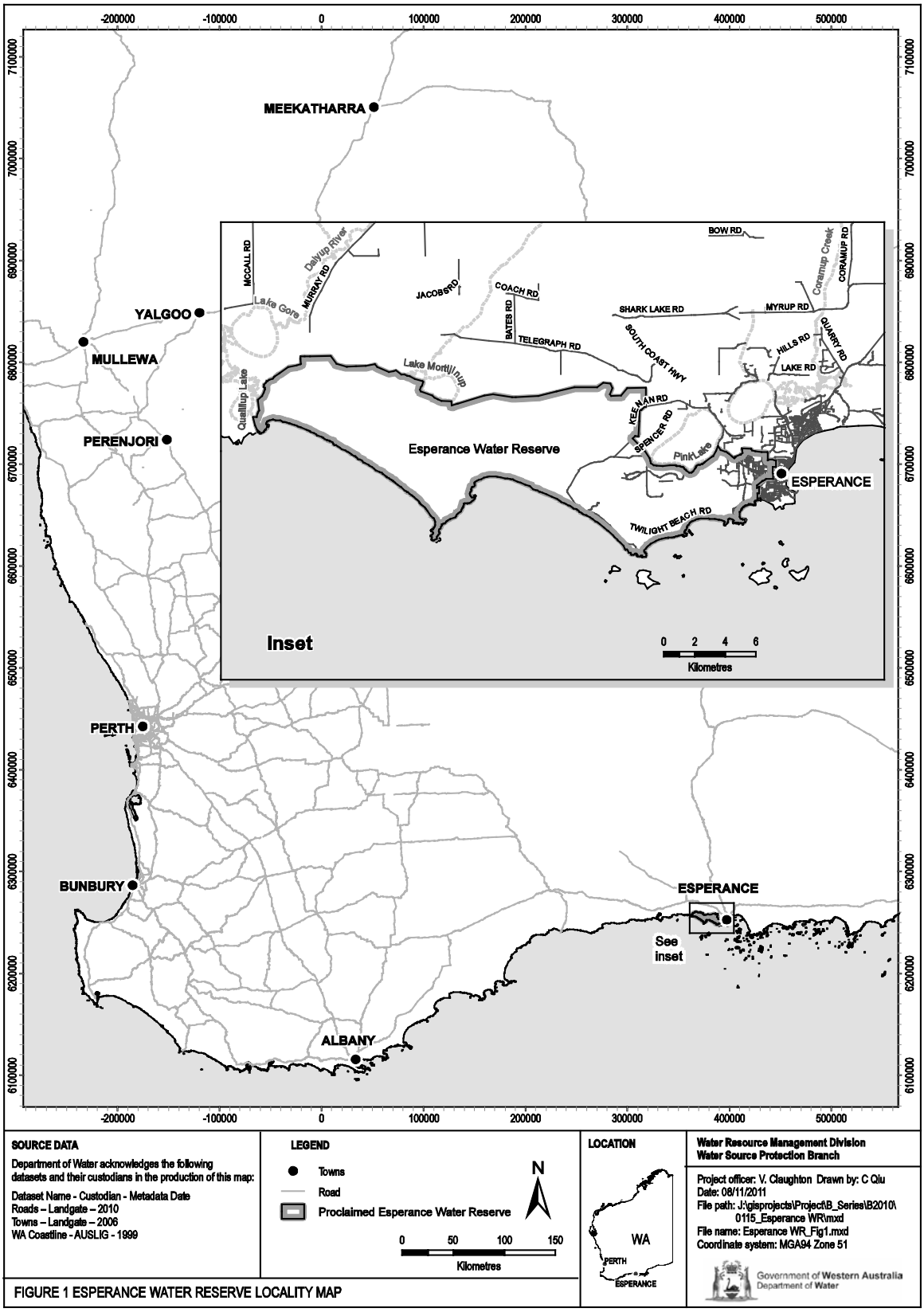
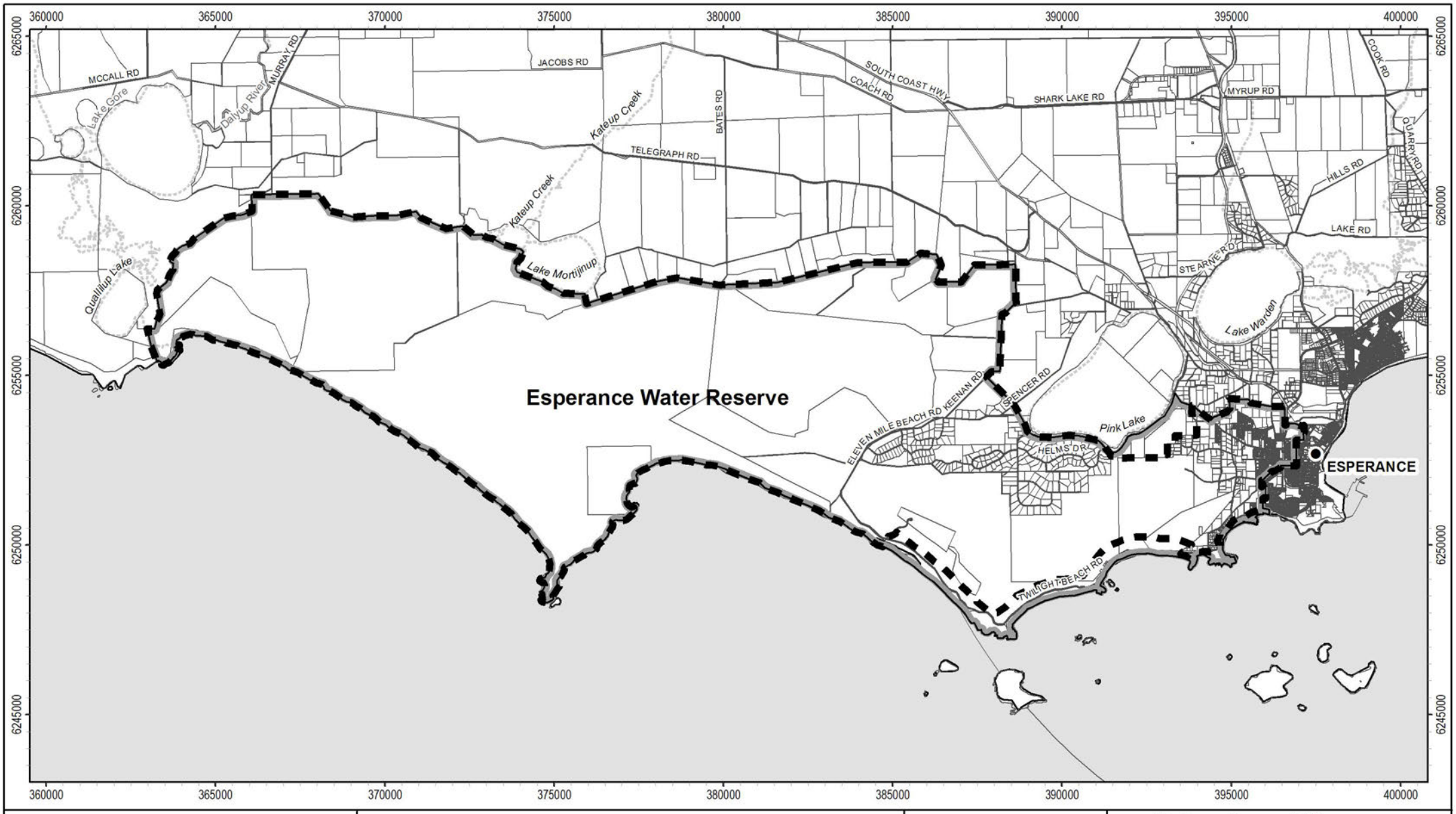


FIGURE 1 ESPERANCE WATER RESERVE LOCALITY MAP



SOURCE DATA

Department of Water acknowledges the following datasets and their custodians in the production of this map:

Dataset Name - Custodian - Metadata Date
Roads – Landgate – 2010
Cadastre - Landgate - 2011

LEGEND

- Towns
- Roads
- Proposed Esperance Water Reserve
- Existing Esperance Water Reserve
- Cadastre

N

0 1 2 3 4 5
Kilometres

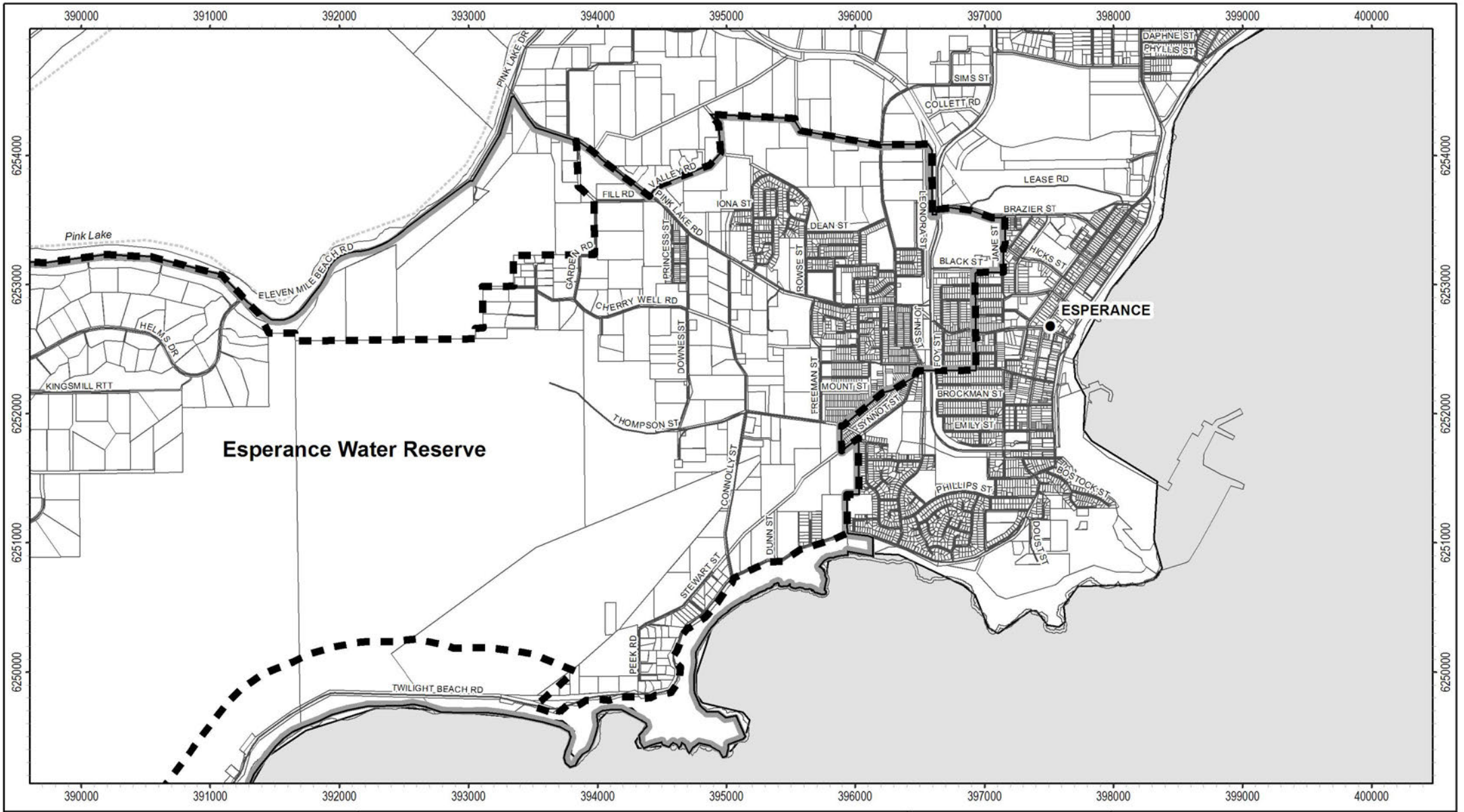
LOCATION

Water Resource Management Division
Water Source Protection Branch

Project officer: V. Claughton Drawn by: C Qiu
Date: 08/11/2011
File path: J:\gisprojects\Project\B_Series\B2010\0115_Esperance WR\mxd
File name: Esperance WR_Fig2.mxd
Coordinate system: MGA94 Zone 51

Government of **Western Australia**
Department of **Water**

FIGURE 2 EXISTING AND PROPOSED ESPERANCE WATER RESERVE BOUNDARIES



SOURCE DATA

Department of Water acknowledges the following datasets and their custodians in the production of this map:

Dataset Name - Custodian - Metadata Date
Roads – Landgate – 2010
Cadastre - Landgate - 2011

LEGEND

- Towns
- Roads
- Proposed Esperance Water Reserve
- Existing Esperance Water Reserve
- Cadastre

N

0 0.5 1
Kilometres

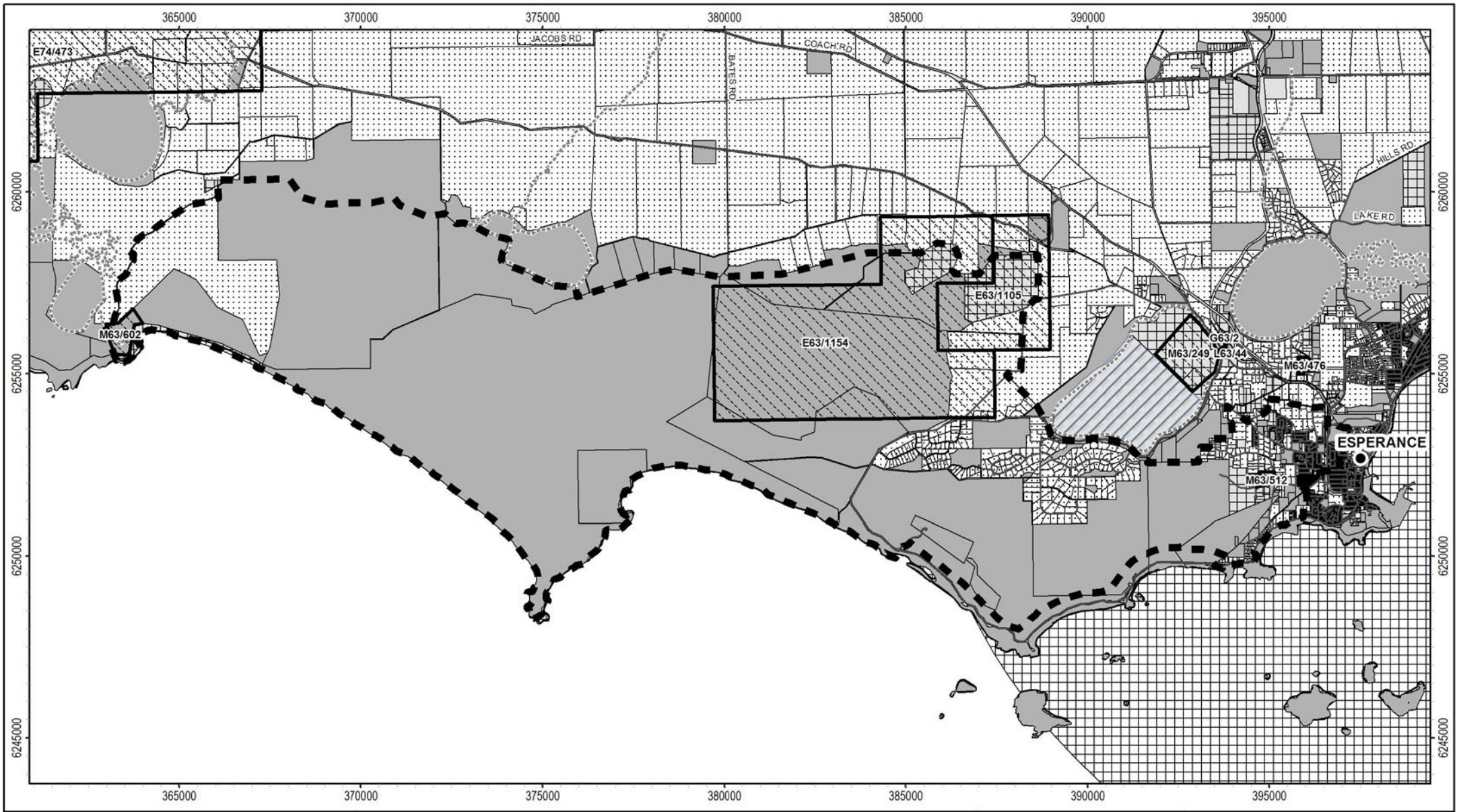
LOCATION

Water Resource Management Division
Water Source Protection Branch

Project officer: V. Claughton Drawn by: C Qiu
Date: 13/01/2012
File path: J:\gisprojects\Project\B_Series\B2010\0115_Esperance WR\mxd\18012012
File name: Esperance WR_Fig3.mxd
Coordinate system: MGA94 Zone 51

Government of **Western Australia**
Department of **Water**

FIGURE 3 EASTERN SECTION OF THE EXISTING AND PROPOSED ESPERANCE WATER RESERVE BOUNDARIES



SOURCE DATA

Department of Water acknowledges the following datasets and their custodians in the production of this map:

Dataset Name - Custodian - Metadata Date
Roads – Landgate – 2010
Cadastre, Land Tenure - Landgate - 2011
Mining Tenement Data - Dept. of Industry and Resources - 2010

LEGEND

- Towns
- Roads
- River
- Mining Tenements
- Proposed Esperance WR

Cadastre, Land Tenure

- Crown Lease
- Crown Reserve
- Freehold
- Unallocated Crown Land
- Water

N

0 1 2 3 4
Kilometers

LOCATION

Water Resource Management Division
Water Source Protection Branch

Project officer: V. Claughton Drawn by: C Qiu
Date: 13/01/2012
File path: J:\gisprojects\Project\B_Series\B2010\0115_Esperance WR\mxd\18012012
File name: Esperance WR_Fig4.mxd
Coordinate system: MGA94 Zone 51

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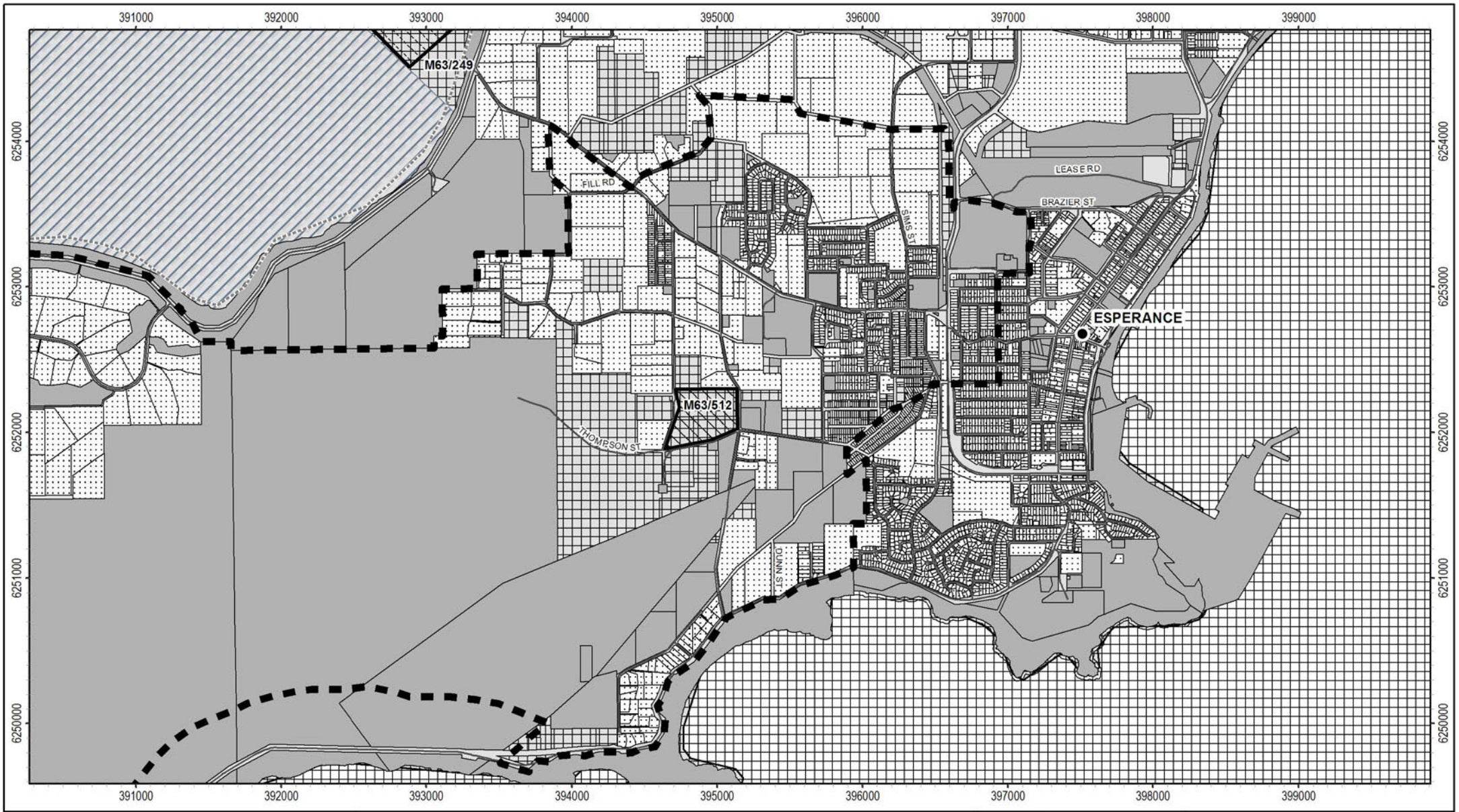
Department of **Water**

FIGURE 4 LAND USE, ACTIVITIES AND TENURE IN AND AROUND THE ESPERANCE WATER RESERVE



SOURCE DATA

Department of Water acknowledges the following datasets and their custodians in the production of this map:

Dataset Name - Custodian - Metadata Date
Roads – Landgate – 2010
Cadastre, Land Tenure - Landgate - 2011
Mining Tenement Data - Dept. of Industry and Resources - 2010

LEGEND

- Towns
- Roads
- River
- Mining Tenements
- Proposed Esperance WR

Cadastre, Land Tenure

- Crown Lease
- Crown Reserve
- Freehold
- Unallocated Crown Land
- Water

N

0 0.5 1
Kilometers

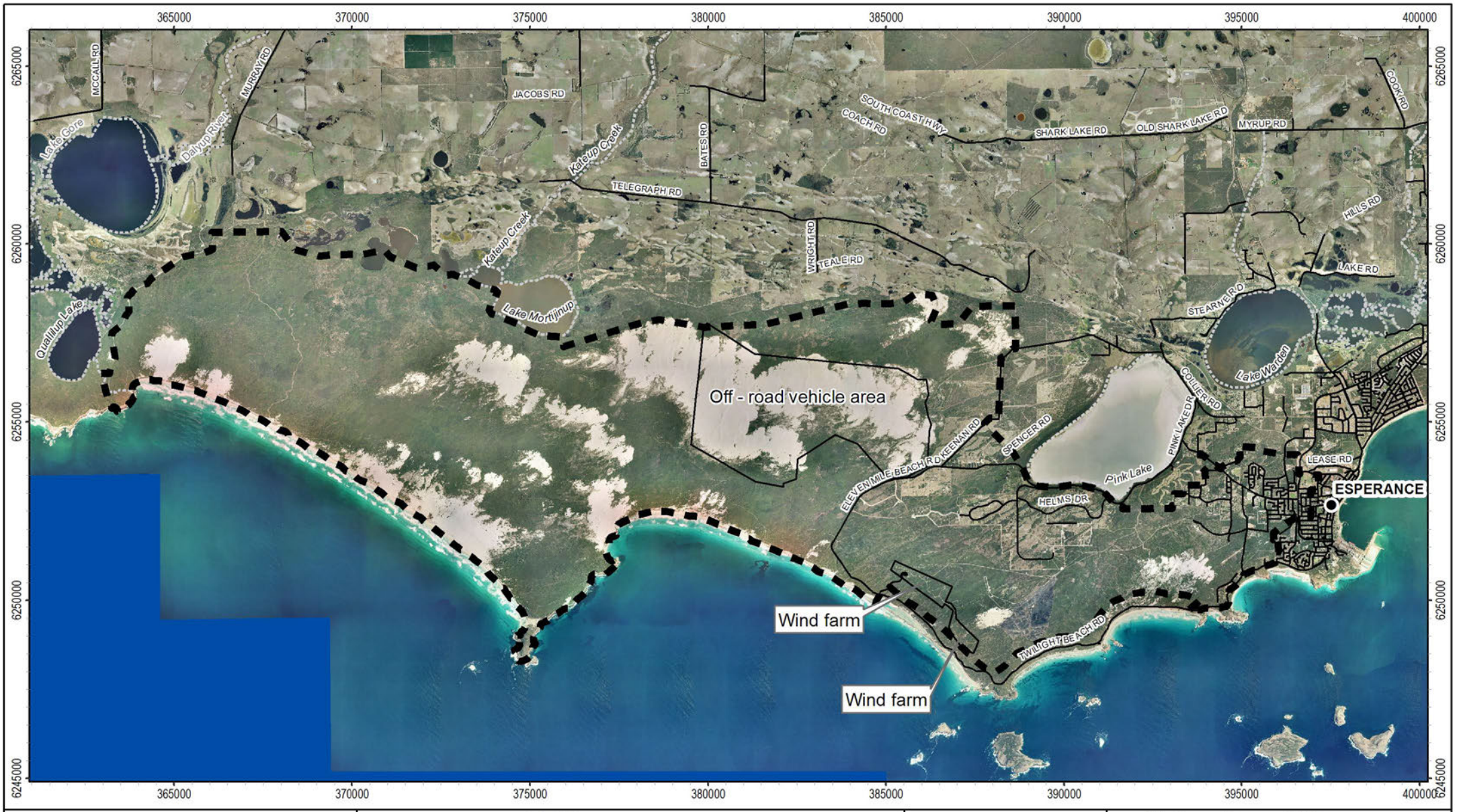
LOCATION

Water Resource Management Division
Water Source Protection Branch

Project officer: V. Claughton Drawn by: C Qiu
Date: 13/01/2012
File path: J:\gisprojects\Project\B_Series\B2010\0115_Esperance WR\mxd\18012012
File name: Esperance WR_Fig5.mxd
Coordinate system: MGA94 Zone 51

Government of **Western Australia**
Department of **Water**

FIGURE 5 LAND USE, ACTIVITIES AND TENURE IN AND AROUND THE EASTERN SECTION OF THE ESPERANCE WATER RESERVE



SOURCE DATA

Department of Water acknowledges the following datasets and their custodians in the production of this map:

Dataset Name - Custodian - Metadata Date
Roads – Landgate – 2010
Aerial Photography - Landgate -
Esperance 50cm - 2007

LEGEND

- Towns
- Proposed Esperance Water Reserve
- Roads

N

0 1 2 3 4 5
Kilometres

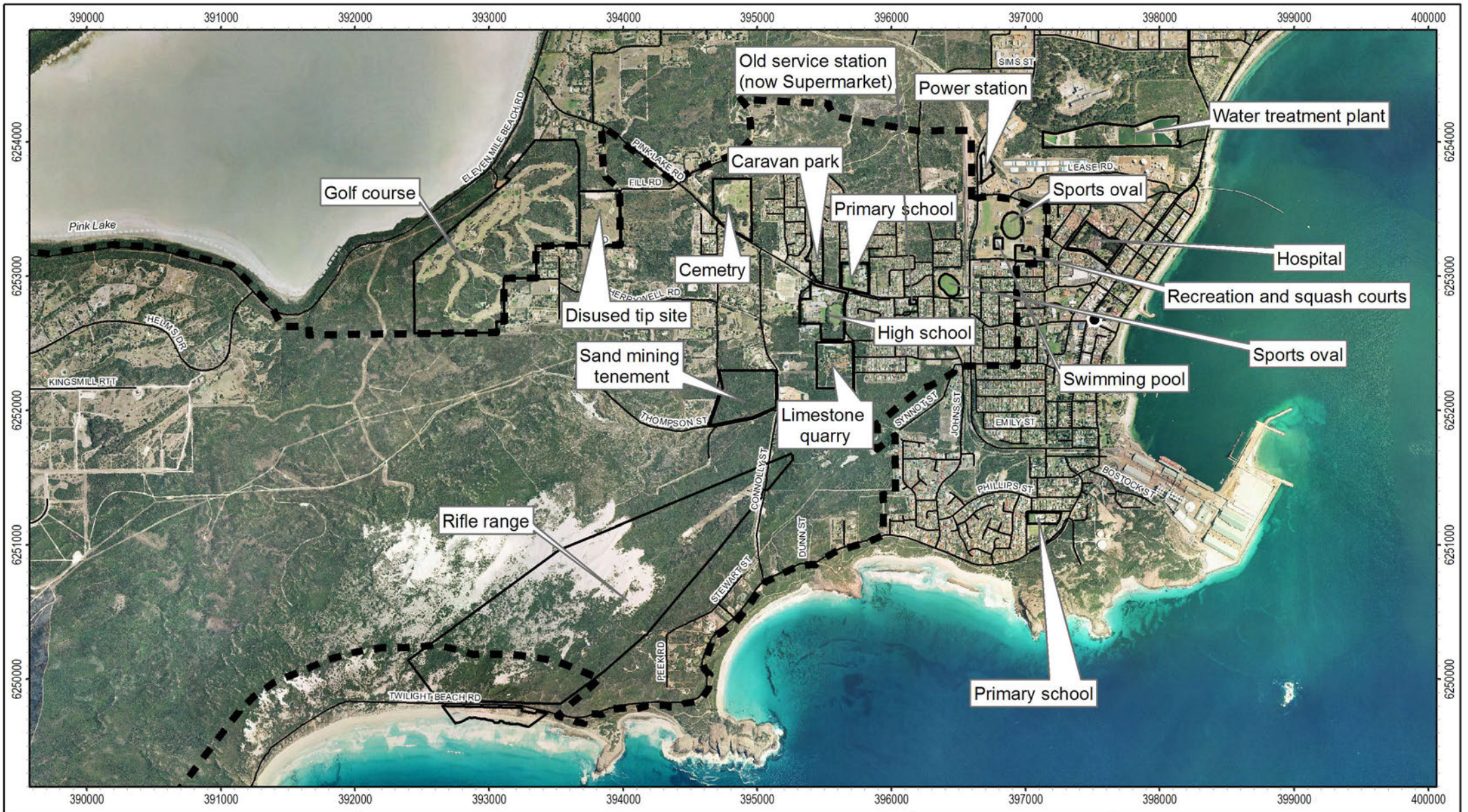
LOCATION

Water Resource Management Division
Water Source Protection Branch

Project officer: V. Claughton Drawn by: C Qiu
Date: 17/01/2012
File path: J:\gisprojects\Project\B_Series\B2010\0115_Esperance WR\mxd\18012012
File name: Esperance WR_Fig6.mxd
Coordinate system: MGA94 Zone 51

Government of **Western Australia**
Department of **Water**

FIGURE 6 AERIAL PHOTOGRAPHY AND LAND USES IN THE ESPERANCE WATER RESERVE



SOURCE DATA

Department of Water acknowledges the following datasets and their custodians in the production of this map:

Dataset Name - Custodian - Metadata Date
Roads – Landgate – 2010
Aerial Photography - Landgate -
Esperance 50cm - 2007

LEGEND

- Towns
- Proposed Esperance Water Reserve
- Roads

N

0 0.5 1
Kilometres

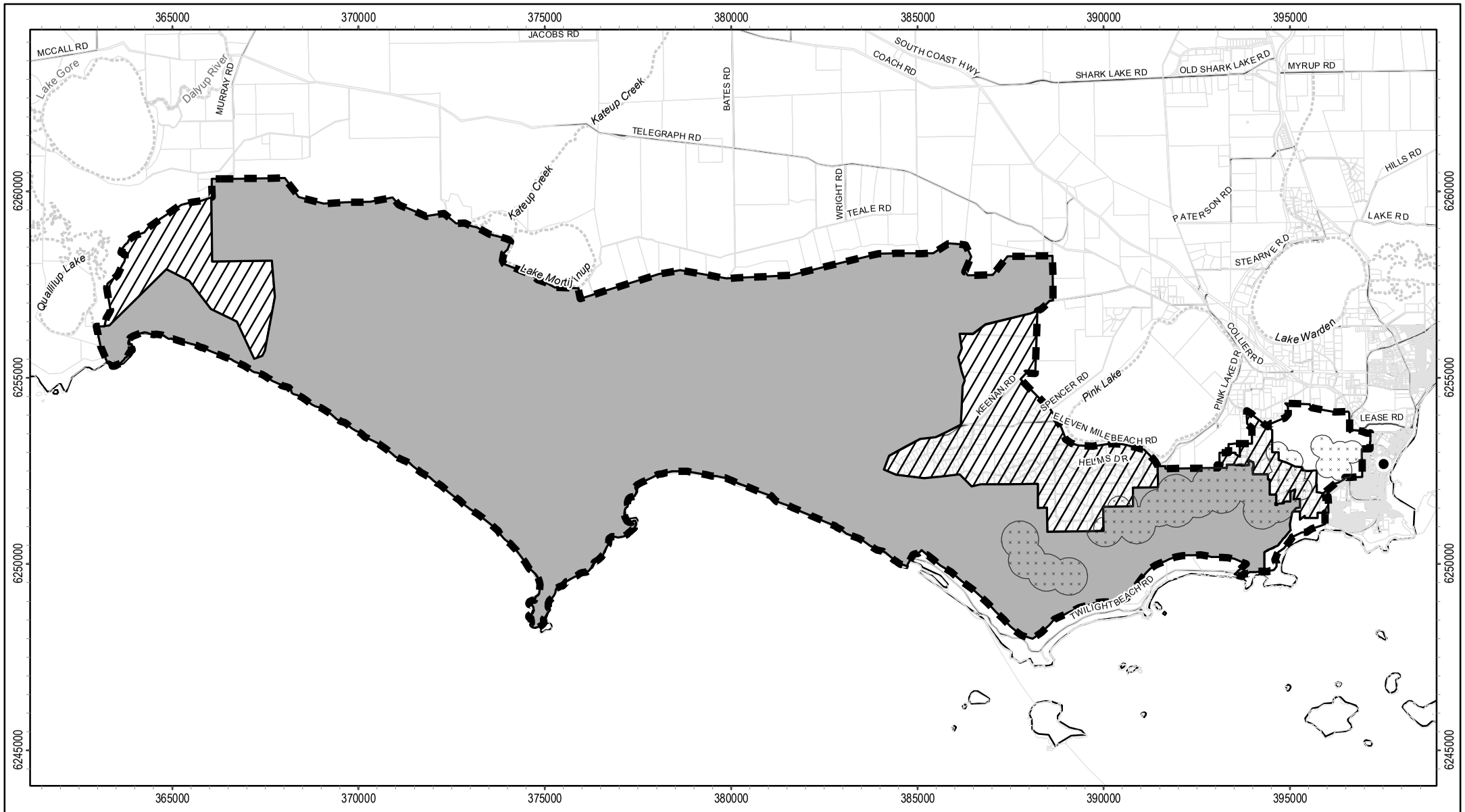
LOCATION

Water Resource Management Division
Water Source Protection Branch

Project officer: V. Claughton Drawn by: C Qiu
Date: 13/01/2012
File path: J:\gisprojects\Project\B_Series\B2010\0115_Esperance WR\mxd\18012012
File name: Esperance WR_Fig7.mxd
Coordinate system: MGA94 Zone 51

Government of **Western Australia**
Department of **Water**

FIGURE 7 AERIAL PHOTOGRAPHY AND LAND USES IN EASTERN SECTION OF THE ESPERANCE WATER RESERVE



SOURCE DATA

Department of Water acknowledges the following datasets and their custodians in the production of this map:

Dataset Name - Custodian - Metadata Date
Roads – Landgate – 2010
Cadastre - Landgate - 2011
River - DoW - 2007

LEGEND

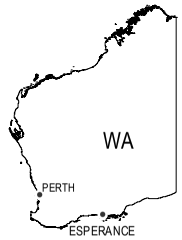
- Towns
- Roads
- Cadastre
- River
- Wellhead Protection Zone
- Proposed Esperance WR
- Priority One
- Priority Two
- Priority Three

N

0 2 4

Kilometers

LOCATION



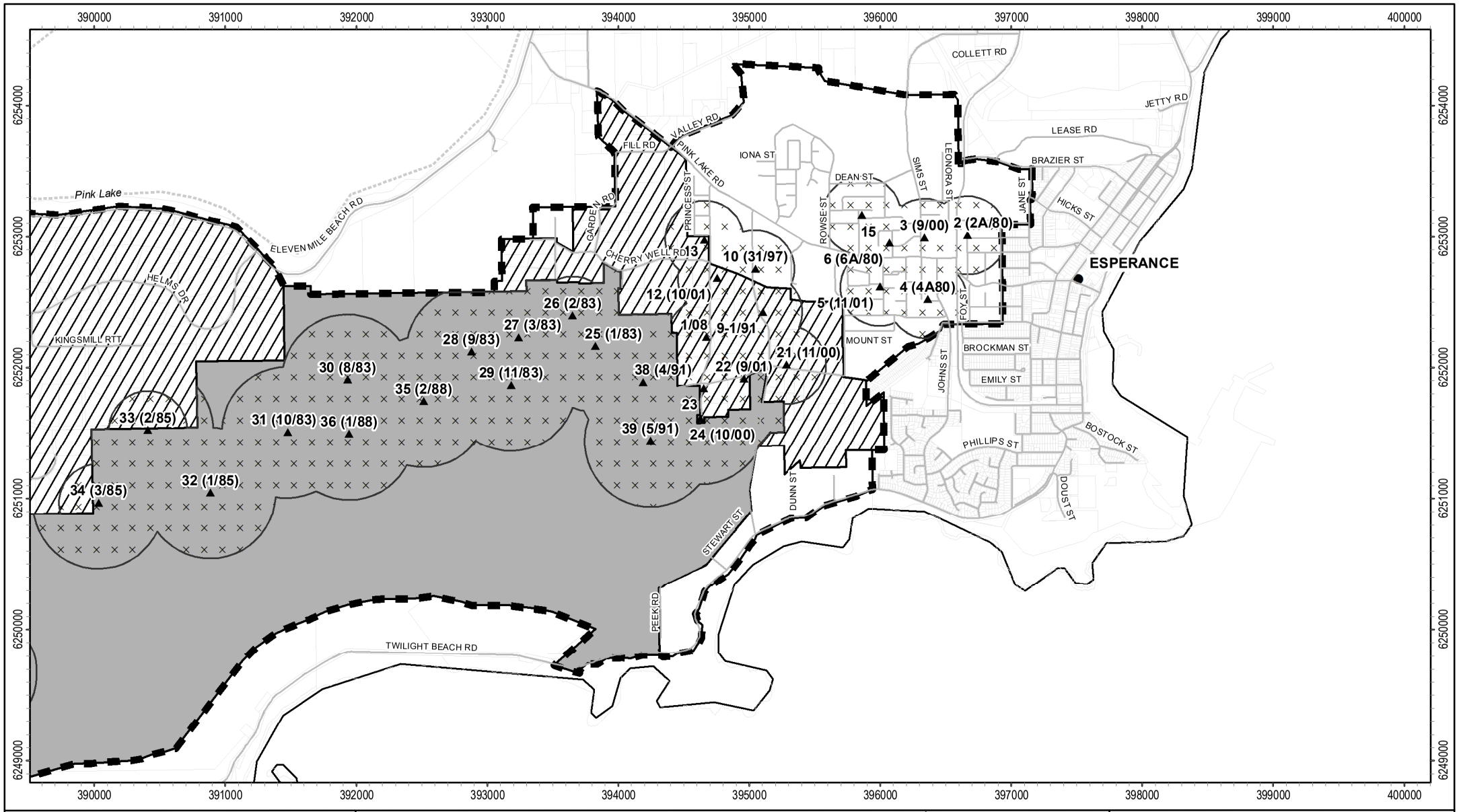
Water and Land Use Division
Water Source Protection Planning Branch

Project officer: V. Claughton Drawn by: C Qiu
Date: 07/03/2013
File path: J:\gisprojects\Project\B_Series\B2010\0115_Esperance WR\mxd\18012012
File name: Esperance WR_Fig8.mxd
Coordinate system: MGA94 Zone 51

Government of **Western Australia**
Department of **Water**

FIGURE 8 PROPOSED BOUNDARY, PRIORITY AREAS AND WELLHEAD PROTECTION ZONES OF THE ESPERANCE WATER RESERVE

This figure has been amended due to a mapping technical error which incorrectly showed a small P2 area as P3. The priority areas on this figure are now correct.



SOURCE DATA

Department of Water acknowledges the following datasets and their custodians in the production of this map:

Dataset Name - Custodian - Metadata Date
Roads – Landgate – 2010
Cadastre - Landgate - 2011
River - DoW - 2007

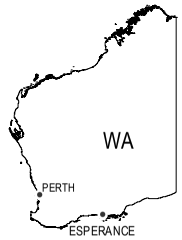
LEGEND

- Production Bore
- Towns
- Roads
- Cadastre
- River
- Wellhead Protection Zone
- Proposed Esperance WR
- Priority One
- Priority Two
- Priority Three

N

0 0.5 1
Kilometres

LOCATION



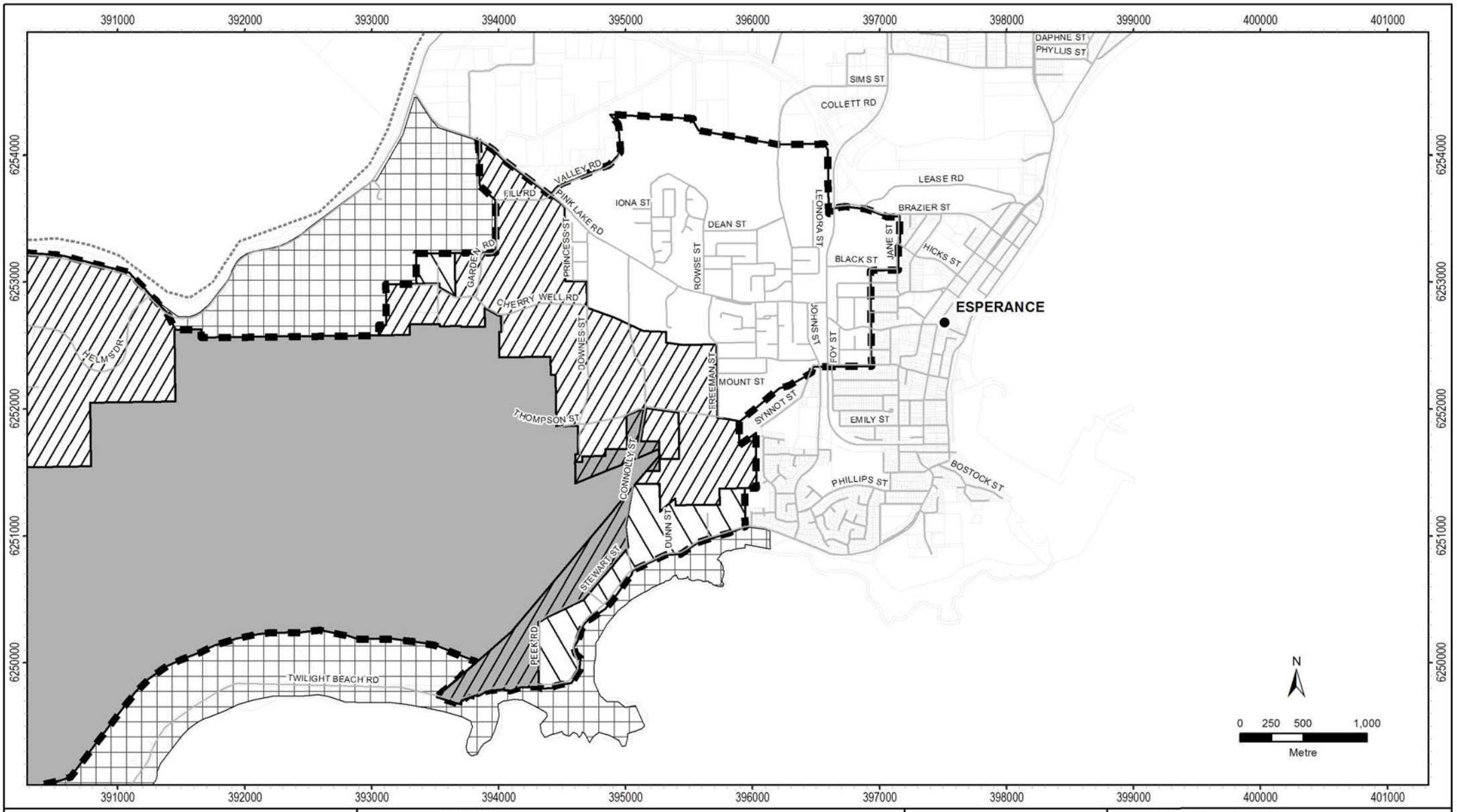
Water and Land Use Division
Water Source Protection Planning Branch

Project officer: V. Claughton Drawn by: C Qiu
Date: 07/03/2013
File path: J:\gisprojects\Project\B_Series\B2010\0115_Esperance WR\mxd\18012012
File name: Esperance WR_Fig9.mxd
Coordinate system: MGA94 Zone 51

Government of **Western Australia**
Department of **Water**

FIGURE 9 EASTERN SECTION OF THE PROPOSED BOUNDARY, PRIORITY AREAS AND WELLHEAD PROTECTION ZONES OF THE ESPERANCE WATER RESERVE

This figure has been amended due to a mapping technical error which incorrectly showed a small P2 area as P3. The priority areas on this figure are now correct.



SOURCE DATA

Department of Water acknowledges the following datasets and their custodians in the production of this map:

Dataset Name - Custodian - Metadata Date
Roads – Landgate – 2010
Cadastre - Landgate - 2011
River - DoW - 2007

LEGEND

- Towns
- Roads
- River
- Cadastre
- Proposed Priority changed area
- Priority Two to One
- Priority Two to Three
- Proposed Removed Area
- Proposed Esperance WR
- Priority One
- Priority Two
- Priority Three

LOCATION

Water and Land Use Division
Water Source Protection Planning Branch

Project officer: V. Claughton Drawn by: C Qiu
Date: 28/08/2012
File path: J:\gisprojects\Project\B_Series\B2010\0115_Esperance WR\mxd\18012012
File name: Esperance WR_Fig10.mxd
Coordinate system: MGA94 Zone 51

Government of **Western Australia**
Department of **Water**

FIGURE 10 PROPOSED CHANGES TO THE EASTERN SECTION OF ESPERANCE WATER RESERVE

Appendix B — Water quality data

The information provided in this appendix has been supplied by the Water Corporation.

The Water Corporation has monitored the raw (source) water quality from Esperance Borefield in accordance with the *Australian Drinking Water Guidelines* (ADWG) and interpretations agreed to with the Department of Health. This data shows the quality of water in the catchment. The raw water is regularly monitored for:

- aesthetic characteristics (non-health related)
- health-related characteristics, including
    - health-related chemicals
    - microbiological contaminants

The following data represents the quality of raw water from Esperance Borefield. In the absence of specific guidelines for raw water quality, the results have been compared with the ADWG values set for drinking water, which defines the quality requirements at the customer's tap. Any water quality parameters that have been detected are reported; those that on occasion have exceeded the ADWG are in bold and italics to give an indication of potential raw water quality issues associated with this source. The values are taken from ongoing monitoring for the five-year period 1 October 2006 to 31 October 2011.

It is important to appreciate that the raw water data presented does not represent the quality of drinking water distributed to the public. Barriers such as storage and water treatment exist downstream of the raw water to ensure it meets the requirements of the ADWG.

For more information on the quality of drinking water supplied to Esperance refer to the most recent Water Corporation drinking water quality annual report at <watercorporation.com.au> What we do > Water quality > Water quality publications > Most recent *Drinking water quality annual report*.

Aesthetic

Aesthetic water quality analyses for raw water from Esperance Borefield are summarised in the following table.

Aesthetic detections for Esperance Borefield

Parameter	Units	ADWG aesthetic guideline value*	Paine Rd Pre Tmt SP		Thompson Pre Tmt SP	
			Range	Median	Range	Median
Chloride	mg/L	250	150 - 185	175	180 - 230	205
Colour - True	TCU	15	<1 - 3	2	<1 - 2	<1
Hardness as CaCO3	mg/L	200	***300 – 390***	***357***	***320 – 350***	***335***
Iron unfiltered	mg/L	0.3	<0.003 – 0.65	<0.003	<0.003 - 1	0.06
Sodium	mg/L	180	N/A	N/A	97 - 120	110
Total filterable solids by summation	mg/L	500	***797 – 859***	***849***	***754 – 828***	***809***
Turbidity	NTU	5	<0.1 – **5.2**	<0.1	<0.1 - **32**	0.3
pH (measured in lab)	No unit	6.5 – 8.5	7.26 – 7.79	7.37	7.38 – 7.97	7.6
Zinc	mg/L	3	0.04#	0.04#	0.02#	0.02#

* An aesthetic guideline value is the concentration or measure of a water quality characteristic that is associated with good quality water.

Only one sampling occasion

Health related

Health-related chemicals

Raw water from Esperance Borefield is analysed for chemicals that are harmful to human health including inorganics, heavy metals, industrial hydrocarbons and pesticides. Health related water quality parameters that have been detected in the source are summarised in the following table.

Health-related detections for Esperance Borefield

Parameter	Units	ADWG health guideline value*	Paine Rd Pre Tmt SP		Thompson Pre Tmt SP	
			Range	Median	Range	Median
Barium	mg/L	0.7	0.016#	0.016#	0.018#	0.018#
Boron	mg/L	4	0.08#	0.08#	0.07#	0.07#
Chromium	mg/L	0.05	N/A	N/A	0.001#	0.001#
Copper	mg/L	2	0.009#	0.009#	0.006#	0.006#

Parameter	Units	ADWG health guideline value*	Paine Rd Pre Tmt SP		Thompson Pre Tmt SP	
			Range	Median	Range	Median
Fluoride	mg/L	1.5	0.4 – 0.5	0.45	0.4 – 0.5	0.45
Manganese unfiltered	mg/L	0.5	<0.002 – 0.008	<0.002	<0.002 – 0.012	<0.002
Nitrate as nitrogen	mg/L	11.29	5.3 – 10.5	7.4	1.4 - 3	2.4
Nitrite as nitrogen	mg/L	0.91	<0.002 – 0.13	0.007	<0.002 – 0.003	<0.002
Nitrite plus nitrate as N	mg/L	11.29	5 - 10	7.55	1.4 – 3.4	2.45
Radon-222	Bq/L	100	0.072 – 1.98	1.19	0.511 – 2.13	1.08
Sulphate	mg/L	500	51 – 70	62	28 – 38	29
Uranium	mg/L	0.02	N/A	N/A	0.001#	0.001#

* A health guideline value is the concentration or measure of a water quality characteristic that, based on present knowledge, does not result in any significant risk to the health of the consumer over a lifetime of consumption (NHRMC & ARMCANZ, 2011).

† The guideline value of 11.29 mg/L (as nitrogen) has been set to protect bottle fed infants under three months of age. Up to 22.58 mg/L (as nitrogen) can be safely consumed by adults and children over three months of age.

Only one sampling occasion

All parameters detected in the raw water sampling points from Esperance are known to naturally occur in groundwater sources. It is possible that elevated nitrate occurs within the aquifer due to residential development and the use of fertilisers within special rural zones. As part of the Operating Strategy for Esperance, the bores with elevated nitrates are blended to minimise the level of nitrate delivered into the reticulation.

Microbiological contaminants

Microbiological testing of raw water samples from Esperance Borefield is currently conducted on a monthly basis. *Escherichia coli* counts are used as an indicator of the degree of recent faecal contamination of the raw water from warm-blooded animals.

A detection of *Escherichia coli* in raw water abstracted from any bore may indicate contamination of faecal material through ingress into the bore, or recharge through to the aquifer (depending on the aquifer type).

During the review period, positive *Escherichia coli* counts at very low levels were recorded in 8 samples taken from the Paine Rd raw water point and 8 samples taken from the Thompson Road raw water point, which is 9% of total samples taken. Water is disinfected with chlorine to ensure the microbiological quality of the drinking water supplied to customers.

Appendix C — Land use, potential water quality risks and recommended protection strategies

Land use/activity	Potential water quality risks		Considerations for management	Current preventive measures	Recommended protection strategies [3]
	Hazard	**Management priority**			
Urban					
Urban development (sewered) • residential • commercial • schools • caravan park • public swimming pool	Nutrients	Medium	There are a number of bores within the urban area. Deep sewerage was provided to most residential and commercial areas in the mid to late 1980s. Houses are as close as 10 m to bores (less than 1 year groundwater flow time of travel). Bores within this area are screened at depths from around 8 m to 15 m.	• water quality monitoring • blending of water • bore sealing	• Community education in relation to protecting the drinking water source e.g. limiting fertiliser and pesticide application, disposing of chemicals properly. • Ensure the public swimming pool is managed in accordance with best management practices as recommended in WQPN no. 55: *Swimming pools.*
	Chemicals	Medium			
	Hydrocarbons	Low			
	Pathogens	Low			
Urban development (unsewered – current and historic) • residential • school	Nutrients	High	A few residential areas and a primary school still have onsite wastewater disposal via septic tanks. Unsewered houses are as close as 40 m from one bore (less than 1 year groundwater flow time of travel). Bores within this area are screened at depths from around	• water quality monitoring • blending of water • bore sealing	• Community education in relation to protecting the drinking water source. • Encourage regular inspection and maintenance of septic tank systems • Investigate the potential for the remaining unsewered areas to be connected to deep sewer. • Continue monitoring the
	Chemicals	Medium			

Land use/activity	Potential water quality risks		Considerations for management	Current preventive measures	Recommended protection strategies [3]
	Hazard	**Management priority**			
	Hydrocarbons	Low	8 m to 15 m. There is a nitrate plume beneath the urban area. Concentrations have generally been decreasing since connection of most properties to deep sewer but recent increases have been observed in some bores.		movement of and concentrations within the nitrate plume. • Investigate the source and management of recent increases in nitrate concentrations in some bores.
	Pathogens	High			
Cemetery	Nutrients	Low	Groundwater flow time of travel to the closest bore is around 20 years. The bore is screened at a depth of around 12 m.	• water quality monitoring • blending of water	• Encourage best management practices as recommended in *Environmental guidelines for the establishment and maintenance of turf and grassed areas.* • Pesticide application to be in accordance with Circular no. PSC 88: *Use of herbicides in water catchment areas.*
	Chemicals	Low			
Parks and ovals	Nutrients	Medium	Some bores are located immediately adjacent to parks and ovals.	• water quality monitoring • blending of water	
	Chemicals	Medium			
Former service station	Hydrocarbons	Not applicable	Closest bore is around 150 m from the site and screened at a depth of around 15 m. Post closure management of site is unknown. The former service station site is now a supermarket.	• water quality monitoring • blending of water	• Obtain decommissioning conditions from the Department of Mines and Petroleum and investigate the process used to decommission the former service station. Request the site be assessed under the *Contaminated Sites Act*.
	Heavy metals	Not applicable			

Land use/activity	Potential water quality risks		Considerations for management	Current preventive measures	Recommended protection strategies [3]
	Hazard	**Management priority**			
Rural residential					
Rural residential	Nutrients	Medium	Lot sizes range from around 2 ha to 8 ha. Some larger lots have not yet been subdivided. Onsite wastewater disposal via septic tanks. Horses, sheep and other domestic animals kept on some lots.	• water quality monitoring • blending of water • local planning scheme provisions	• Community education in relation to protecting the drinking water source. • Encourage regular inspection and maintenance of septic tank systems. • Ensure compliance with stocking rate requirements for horses and other stock.
	Pathogens	High			
	Chemicals	Medium			
Crown land					
Rifle range	Heavy metal	Low	Groundwater flow time of travel to the closest bore is around 8-10 years.	• water quality monitoring • blending of water	
	Nutrients	Low			
Off-road vehicle use	Hydrocarbons	Low	There is significant illegal off-road vehicle access to the borefield along the borefield roads and on new four-wheel drive and motorbike tracks that have been created. There is a designated off-road vehicle area on Crown reserve 34777 to the west of the borefield.	• water quality monitoring • blending of water • signage	• Encourage use of the designated area and discourage the use of borefield tracks. • Ensure future bores are located away from the designated off-road area. • Implement the recommendations in the off-road vehicles section of the *Esperance Coastal Management Plan*, 2002.

Land use/activity	Potential water quality risks		Considerations for management	Current preventive measures	Recommended protection strategies [3]
	Hazard	**Management priority**			
Rubbish dumping • domestic rubbish • car bodies	Nutrients	Medium	Illegal rubbish dumping occurs in the Thompson Street borefield, sometimes close to bores. Water Corporation liaises with the Shire of Esperance (SoE) to ensure removal of rubbish.	• water quality monitoring • blending of water • Water Corporation surveillance	• Community education about the risks of rubbish dumping in the drinking water source area e.g. through signage. • Continued liaison between Water Corporation and Shire of Esperance.
	Chemicals	Medium			
	Hydrocarbons	Medium			
Other					
Extractive industry • quarry • proposed sand mine	Hydrocarbons	Low	The quarry is around 250 m to 300 m from the nearest bore. Shire of Esperance conditions for the quarry include: • separation distance of at least 2m between extraction and the water table • management of the site to be in accordance with WQPN no. 15: *Extractive industries near sensitive water resources* • the proposed sand mine is currently being assessed by Department of Mines and Petroleum. No refuelling, maintenance or storage of chemicals is proposed to occur onsite. Extraction is not proposed within 4.5 m of water table	• water quality monitoring • blending of water • development conditions	• Ensure compliance with Shire of Esperance and Department of Mines and Petroleum conditions. • Ensure any fuel storage is in accordance with best management practices e.g. within a bunded compound with impervious flooring.

Land use/activity	Potential water quality risks		Considerations for management	Current preventive measures	Recommended protection strategies [3]
	Hazard	**Management priority**			
Roads and railways	Hydrocarbons	Medium	A major transport road (Harbour Road) and railway line to the Esperance Port passes through the water reserve. There are many local roads close to bores within the urban area. Road drainage sumps are located immediately adjacent to some bores.	• water quality monitoring • blending of water • LEMC response to spills and accidents	• Road drainage should be directed away from the bores. • Increased signage along major transport routes to inform people of the water reserve and emergency contact numbers. • Continued LEMC response and liaison with Water Corporation/Department of Water in the event of a spill.
	Chemicals	Medium			
Borefield operation					
Groundwater abstraction	Salinity	High	Increased salinity has been observed in some bores. Salinity has been increasing in some areas. Modelling and monitoring has identified areas potentially at risk of saltwater intrusion.	• borefield operation and blending of water • water quality, water level and salt water interface monitoring • Water Corporation operating strategy	• Ensure operation of borefield is in accordance with Water Corporation's operating strategy. • Modelling results to be incorporated into future operating strategies.

Land use/activity	Potential water quality risks		Considerations for management	Current preventive measures	Recommended protection strategies [3]
	Hazard	**Management priority**			
Potential future land uses					
Future industrial	Chemicals	Medium	A large area to the north of Dean Street is zoned future residential. To the east of this is an area zoned future industrial/commercial. A number of lots along and just to the north of Twilight Beach Road are zoned residential but have not yet been subdivided.	• planning process and Department of Water advice on development applications	• Future urban development should be connected to deep sewer. • Future industrial development to be in accordance with WQPN no. 25: *Land use compatibility in public drinking water source areas,* operated in accordance with best management practices as recommended by relevant guidance documents and should be connected to deep sewer.
	Hydrocarbons	Medium			
	Heavy metals	Medium			
Future residential/ commercial	Nutrients	Medium			
	Chemicals	Medium			
	Hydrocarbons	Low			
	Pathogens	High			

[3] For brevity, the full details of these water quality protection notes and water quality protection guidelines are provided in the reference list.

Appendix D — Photographs

Figure D1 Bore 15 and adjacent park and residential area

Figure D2 Rural residential area near Bore 33

Figure D3 Cemetery

Figure D4 Bore 41 and surrounding vegetated reserve

Figure D5 View over part of the water reserve and Borefield

Figure D6 Four-wheel drive and motorbike track off the borefield road

List of shortened forms

ADWG	*Australian Drinking Water Guidelines*
AHD	Australian height datum
ANZECC	Australian and New Zealand Environment Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
Bq/L	becquerel per litre
CFU	colony forming units
DEC	Department of Environment and Conservation
EC	electrical conductivity
FESA	Fire and Emergency Services Authority of Western Australia
GL	Gigalitre
ha	Hectare
HAZMAT	hazardous materials
kL	kilolitre
km	kilometre
LEMC	local emergency management committee
m	metres
mg/L	milligram per litre
mL	millilitre
MPN	most probable number
NHMRC	National Health and Medical Research Council
NRMMC	Natural Resource Management Ministerial Council
NTU	nephelometric turbidity units
PSC 88	public sector circular number 88
PDWSA	public drinking water source area
TCU	true colour units
TDS	total dissolved solids

TFSS	total filterable solids by summation
TmT	Treatment
SP	Sample Point
WAPC	Western Australian Planning Commission
WESTPLAN–HAZMAT	Western Australian plan for hazardous materials
WHPZ	wellhead protection zone
WQPG	Water quality protection guideline
WQPN	Water quality protection note

Glossary

Abstraction	The pumping of groundwater from an aquifer, or the removal of water from a waterway or water body.
Adsorb	Adsorb means to accumulate on the surface of something.
Aesthetic guideline value	The concentration or measure of a water quality characteristic that is associated with acceptability of water to the consumer, e.g. appearance, taste and odour (NHMRC & NRMMC 2011).
Allocation	The quantity of water that a licensee is permitted to abstract is their allocation, usually specified in kilolitres per annum (kL/a).
Australian Drinking Water Guidelines	The *National water quality management strategy: Australian Drinking Water Guidelines 6*, 2011 (NHMRC & NRMMC 2011) (ADWG) outlines acceptable criteria for the quality of drinking water in Australia (see this plan's Bibliography).
Australian height datum	Australian height datum is the height of land in metres above mean sea level. For example, the AHD is +0.026 m at Fremantle.
Becquerel	A measurement of radioactivity, where 1 Bq is equal to one nuclear transformation per second.
Catchment	The physical area of land which intercepts rainfall and contributes the collected water to surface water (streams, rivers, wetlands) or groundwater.
Department of Environment and Conservation	The Department of Environment and Conservation was established on 1 July 2006, bringing together the Department of Environment and the Department of Conservation and Land Management.
Effluent	Effluent is treated or untreated liquid, solid or gaseous waste discharged by a process such as through a septic tank and leach drain system.
Gigalitre	A gigalitre is equivalent to 1 000 000 000 litres or one million kilolitres.
Half-life	The time required for one half of a sample of material to disintegrate.
Health guideline value	The concentration or measure of a water quality characteristic that, based on current knowledge, does not result in any significant risk to the health of the consumer over a lifetime of consumption (NHMRC & NRMMC 2011).
Hectare	A measurement of area, equivalent to 10 000 square metres.
Hydrocarbons	A class of compounds containing only hydrogen and carbon, such as

	methane, ethylene, acetylene and benzene. Fossil fuels such as oil, petroleum and natural gas all contain hydrocarbons.
Hydrogeology	The study of groundwater, especially relating to the distribution of aquifers, groundwater flow and groundwater quality.
Leaching/ leachate	The process by which materials such as organic matter and mineral salts are washed out of a layer of soil or dumped material by being dissolved or suspended in percolating rainwater. The material washed out is known as leachate. Leachate can pollute groundwater and waterways.
mg/L	A milligram per litre (0.001 grams per litre) is a measurement of a total dissolved solid in a solution.
Most probable number	Most probable number is a measure of microbiological contamination.
Nephelometric turbidity units	Nephelometric turbidity units are a measure of turbidity in water.
Nutrients	Minerals, particularly inorganic compounds of nitrogen (nitrate and ammonia) and phosphorous (phosphate) dissolved in water which provide nutrition (food) for plant growth.
Pathogen	A disease-producing organism that can cause sickness and sometimes death through the consumption of water, including bacteria (such as *Escherichia coli*), protozoa (such as *Cryptosporidium* and *Giardia*) and viruses.
Pesticides	Collective name for a variety of insecticides, fungicides, herbicides, algicides, fumigants and rodenticides used to kill organisms.
pH	A logarithmic scale for expressing the acidity or alkalinity of a solution. A pH below seven indicates an acidic solution and above seven indicates an alkaline solution.
Pollution	Water pollution occurs when waste products or other substances (effluent, litter, refuse, sewage or contaminated runoff) change the physical, chemical or biological properties of the water, adversely affecting water quality, living species and beneficial uses.
Public drinking water source area	Includes all underground water pollution control areas, catchment areas and water reserves constituted under the *Metropolitan Water Supply Sewerage and Drainage Act 1909* (WA) and the *Country Areas Water Supply Act 1947* (WA).
Public sector circular number	A state government circular produced by the Department of Health providing guidance on appropriate herbicide use within water

88	catchment areas.
Quaternary	The most recent period in the Cainozoic era, from 2 million years to present.
Recharge	Recharge is the action of water infiltrating through the soil/ground to replenish an aquifer.
Recharge area	An area through which water from a groundwater catchment percolates to replenish (recharge) an aquifer. An unconfined aquifer is recharged by rainfall throughout its distribution. Confined aquifers are recharged in specific areas where water leaks from overlying aquifers, or where the aquifer rises to meet the surface.
Scheme supply	Water diverted from a source or sources by a water authority or private company and supplied via a distribution network to customers for urban and industrial use or for irrigation.
Total filterable solids by summation	Total filterable solids by summation is a water quality test which is a total of the following ions: Na (sodium), K (potassium), Ca (calcium), Mg (magnesium), Cl equivalent (chloride), alkalinity equivalent, SO_4 equivalent (sulfate) or S (sulfur) in grams, Fe (iron), Mn (manganese), and SiO_2 (silicon oxide). It is used as a more accurate measure than total dissolved solids (TDS). The higher the value, the more solids that are present and generally the saltier the taste.
Treatment	Application of techniques such as settlement, filtration and chlorination to render water suitable for specific purposes, including drinking and discharge to the environment.
True colour units	True colour units are a measure of degree of colour in water.
Turbidity	The cloudiness or haziness of water caused by the presence of fine suspended matter.
Unconformably	Discontinuity within a geological stratigraphic sequence.
Upconing	Process of saline water that is underlying freshwater in an aquifer, rising through the aquifer due to the pumping of freshwater.
Wastewater	Water that has been used for some purpose and would normally be treated and discarded. Wastewater usually contains significant quantities of pollutant.
Water quality	Water quality is the collective term for the physical, aesthetic, chemical and biological properties of water.

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